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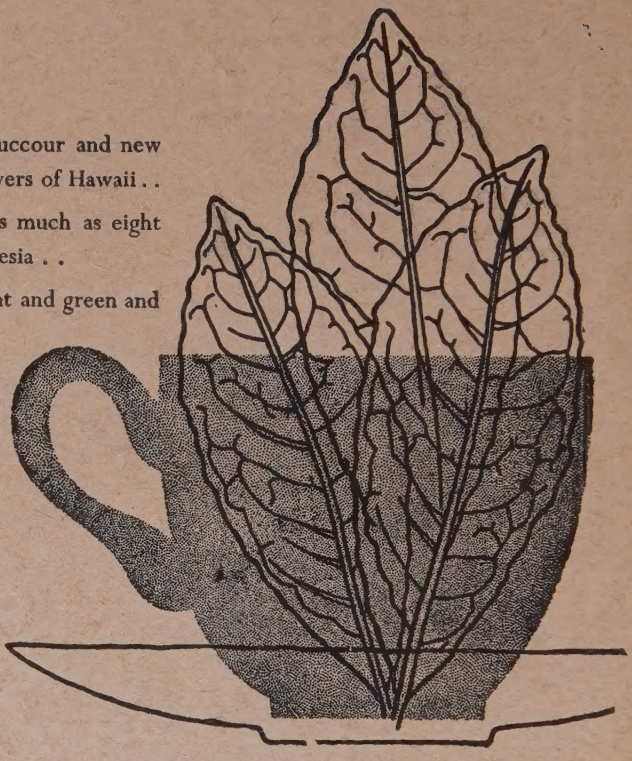

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TROPICAL AGRICULTURIST

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CONTENTS

Page

EDITORIAL

Cotton in Ceylon 105

THE BIOLOGY AND CONTROL OF LEPTOGLOSSUS MEMBRANACEUS, FABRICIUS (FAM. CORDEIAE ORD. HAMIPTERA)

by H. E. Fernando 107

THE EFFECT OF TROPICAL FEEDING STUFFS ON GROWTH AND FIRST YEAR EGG PRODUCTION

by P. Mahadevan, D. G. Panditteseker a, J. S. L. White and V. Arumugam 119

WEED CONTROL IN DRY LAND FARMING

by S. T. W. Kirinde 131

SOIL CONDITIONS AND SEEDLING BLIGHT OF RICE

by A. L. Bertus and D. V. W. Abeygunewardena .. 147

A NOTE ON MAS—AN INDONESIAN VARIETY OF RICE

by J. J. Niles 153

SOME ASPECTS IN THE PLANNING AND ASSESSMENT OF SOIL AND WATER CONSERVATION MEASURES

by V. E. A. Wickremanayake 157

THE INFORMATION SERVICE IN RELATION TO AGRICULTURAL EXTENSION IN CEYLON

by D. E. Schokman 163

METEOROLOGICAL REPORT

Summary for January to June, 1957 177

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EDITORIAL

Cotton in Ceylon

CEYLON'S ANNUAL requirements in cotton textiles amount to 90 million yards. The production of the Wellawatta Mills and the hand looms does not exceed one eighth of this quantity. At present, only a negligible fraction of even the needs of the local industry is supplied by Ceylon-grown cotton. The almost complete dependence on imported supplies of raw cotton has discouraged the growth of Ceylon's textile industry. The decision of the Department of Agriculture to explore the possibility of a striking expansion in Ceylon's cotton acreage is well-timed, particularly in view of Government's announcement of its intention to establish a State-owned textile mill.

Systematic experiments by this department have conclusively proved that medium and fine staple cotton can be grown with striking success under completely rainfed conditions in certain sections of Ceylon's dry zone. The crop can mature with 24 inches of rain, but can tolerate 30 inches if the distribution is satisfactory. Sowing should synchronize with the earliest *maha* rains. If rain in October and November is excessive, the crop runs to leaf. January should not be too wet as soil saturation may lead to shedding of bolls. Picking begins in February, and continues into March ; these months should accordingly be dry. The area selected for cotton should preferably have no pronounced South West Monsoon as the early *yala* rains would spoil tail-end cotton. Apart from rainfall, temperature has important effects on reproduction in cotton ; a critical minimum temperature is necessary for flower initiation. These requirements in precipitation and temperature are completely satisfied in the greater part of the Hambantota District.

A complaint by the Wellawatta Mills that the Cambodia cotton supplied them under the Government Purchase Scheme does not spin a 30^{s} count provoked the commencement in 1937 of the department's programme of cotton improvement. Over the period 1937-44, five medium staples with seed cotton yields of over seven cwt. per acre and a fibre length of over one inch were bred at Tissamaharama. BP. 79 was pre-eminent : its staple exceeded $1\frac{1}{8}$ inch, and the Cotton Technological Laboratories in Matunga and Manchester reported its ability to spin 40^{s} count. For nearly a decade, Ceylon's total acreage was under BP. 79. In recent years, however, the Wellawatta Mills have complained with increasing persistence and vehemence of seed neps in BP. 79. Last year, the Hambantota Cotton Research Station announced the replacement of BP. 79 by the hybrid H.C. 101. The new selection, of which large quantities of seed have been issued for

planting this *maha* season, represents a striking triumph in cotton breeding. Apart from its relative freedom from seed neps, it out-yields BP. 79, has a longer staple and spins a higher count and a stronger yarn. According to the technological reports of the Shirley Institute, Manchester, H.C. 101 has a staple length of 1 10/32 inch, and its highest standard warp count is 44 ; BP. 79 has a staple of 1 7/32 inch, and spins at 38 ^{s} count. It is in the ginning outturn that the superiority of H.C. 101 is particularly manifest : the ginning percentage of H.C. 101 and BP. 79 are 33.8 per cent. and 27.5 per cent. respectively. In every feature except the maturity ratio, H.C. 101 is pre-eminent. The lower maturity ratio is a characteristic which H.C. 101 shares with many fine staples.

Advances in agronomic research in cotton have, however, not been as striking as the breeding advances. Nevertheless, sufficient information on cotton agronomy exists to justify the extension of cotton growing in the area between Walawe Ganga and the Kirindi Oya. Plans for the expansion of the cotton acreage in this area have been drawn up by a Departmental Committee consisting of the Botanist and the Agricultural Research Officer, Dry Farming. Cotton is grown in most countries in soils that are deeper and more retentive of moisture than those in Ceylon's dry zone. Moreover, these soils are extremely vulnerable and tillage practices must be such as would eliminate irreparable damage to soil structure. Nevertheless, the spectacular yields that have been obtained in the Hambantota District leave little doubt that, with efficient management, these soils would prove eminently suitable for cotton.

Timely planting and effective weed-control are crucial factors in successful cotton growing. In Ceylon's cotton belt, the interval during which moisture conditions optimum for germination prevail, does not exceed two weeks. Moreover, cotton is exceedingly sensitive to weed competition. Mechanisation of tillage operations is the obvious answer to these problems.

For many years to come, harvesting of cotton in this country must continue to be done by hand, and will form the most expensive item in cotton production. Apart from considerations of cost, the labour necessary for picking extensive areas does not exist within the cotton belt, and will need to be recruited from outside.

The choice of suitable rotations is probably the thorniest problem in cotton farming. It is the view of the Research Officers of the Department of Agriculture that the ideal system is one of mixed farming in which pastures compose at least two-thirds of the area, and arable crops not more than a third. For the arable area, cotton or a sorghum-pigeon pea mixture may profitably be grown in the *maha* season, and either sunn-hemp or a continuation of the pigeon pea component of the *maha* mixture may cover the ground in *yala*. The projected Cotton State Farm in the Walawe Valley will adopt this system.

THE BIOLOGY AND CONTROL OF *LEPTOGLOSSUS MEMBRANACEUS*, FABRICIUS (FAM. COREIDAE ORD. HAMIPTERA)

By H. E. FERNANDO

(Entomologist—Ceylon Department of Agriculture)

INTRODUCTION

SPECIES of the genus *Leptoglossus* are widely distributed and are pests of economic crops in many parts of the world. *Leptoglossus phyllopus* (L) is found in some southern states of the U. S. A. where it is a pest of citrus (Ebeling 1950, Watson 1940, Friend 1947). *Leptoglossus zonatus* (Dallas) is found in California, breeding on and damaging pomegranate and also attacking citrus (Ebeling 1950). *Leptoglossus gonagra*, F., is recorded in South America where it is a pest of citrus, cucurbits, passiflora and tobacco in Argentina (Bosq 1940) and of citrus in Brazil (Monte 1942). *Leptoglossus australis* is listed as a pest of pumpkin in Fiji (Lever 1945) while *L. biadentatus* is a pest of cucurbits in Australia (May 1946).

Besides being major pests predominantly of cucurbits and citrus, species of *Leptoglossus* are also recorded as being pests of other cultivated crops. In Texas *L. phyllopus* kills sunflower (Helianthus) plants by its feeding (Adams and Gaines 1950) while in the Micronesian Islands *L. membranaceus*, Fabricius, is recorded as a pest of cotton, beans and cucurbits (Esaki 1939 and 1940). *Leptoglossus zonatus* is known to transmit a plant disease, the heart rot of pomegranate caused by *Nematospora coryli* (Burgess and Hawkins 1944) while *L. membranaceus* transmits the same disease on citrus fruits in Sumatra (Muller 1940).

In Ceylon the genus is represented by *L. membranaceus*, which like most of the other species of the genus of economic importance is a pest of cucurbits and citrus. It is not a regular pest of these crops, however, and only rarely does it appear in epidemic proportions to do extensive damage. Such epidemics of this pest have been recorded in Ceylon in 1912, 1936 and 1957. The bionomics of this species in Ceylon has been briefly discussed by Green (1912) and Hutson (1936).

Reported results on the control of these pests have been few. In Florida pyrethrum dusts were reported to give promising results against *L. phyllopus* (Watson *et al* 1938-1939) while in Australia a spray of DDT was reported to give better results than previous treatments against *L. bidentatus* (May 1946). More recently satisfactory reduction of populations of *L. phyllopus* have been reported by Adams *et al* (1950) when dusts combining toxaphene and sulphur or BHC, DDT and Sulphur were used. The scarcity of observations on the behaviour of *L. membranaceus* in Ceylon and the need for developing quick and effective control measures against this pest during the recent epidemic of the pest necessitated a study of these topics. The results of these studies, although relatively incomplete, are reported below.

DESCRIPTION AND LIFE HISTORY OF PEST

Leptoglossus membranaceus is a heavily built insect. Adult females and males are of equal size ranging between 18 m.m. and 24 m.m. in length and between 5.5 m.m. and 8 m.m. in width across the thoracic spines which form the widest point of the body of the insect. The head is elongated and protrudes in front of the thorax. A prothoracic spine on either side and immediately above the base of the forewings extends antro-laterally. The scutellum of the prothorax extends about one third the length of the abdomen. The abdomen is almost completely covered by the hemelytra except for two small subapical dorso-lateral extensions. The antennae are conspicuous and almost as long as the entire body. The pro- and messothoracic legs are slender while the metathoracic legs are stout and heavily built. The femur of the metathoracic legs are thick and covered, especially along their ventral aspect, with large spines. The tibiae of the metathoracic legs are expanded immediately beyond the base into paddle-like or wing-like flattened extensions.

In colour this bug is brownish black dorsally with an orange-red cervical margin of the prothorax and a crescent shaped orange-red band terminating on either side at the base of the cervical spines. Ventrally there is a longitudinal band of orange-red running beneath the eyes, and the thorax and abdomen are brownish black with orange-red spotting. The antennae are brownish black with light brown to orange-red alternating patches. The limbs are black except for the paddle-like expansion of the tibiae of the hind legs which have orange-red markings.

Female bugs lay their pale brown cylindrical eggs end to end and in rows, some extending up to 2½ inches, on stems, leaves and tendrils of cucurbit plants. Egg laying and nymphal development was not observed on citrus plants. The preferred site for egg laying on

cucurbit plants is the tendrils. In this situation the eggs appear to be a part of the tendrils and are distinguished only with difficulty. The eggs hatch in 8 to 10 days with the young nymphs emerging through the opening caused by the displacement of the operculum. The insect undergoes five nymphal instars. The first four nymphal instars possess blood-red heads and abdomens with black thoraces and appendages. The body is sparely covered with black spines. The typical tibial extensions observed in the hind legs of the adult first become apparent in the second instar and progressively increase in size with each succeeding instar. The fifth nymphal instar differs from the preceding instars in that it is predominantly black with small red patches on the head, abdomen and thorax.

HOST PLANTS AND SEASONAL PREVALENCE

Leptoglossus membranaceus has been recorded by Hutson (1936) to feed in Ceylon upon tree tomato (*Cyphomandra betacea*), peach, plum, Cape gooseberry, beans, citrus and cucurbits. However *L. membranaceus* is best known in Ceylon for its serious damage to cucurbits and citrus.

This pest is usually found in most cultivated cucurbit plantings in such small numbers as not to be noticed by cultivators. Periodically however this insect multiplies into vast numbers simultaneously in widely separated areas all over the country so as to cause enormous damage to the cucurbit and citrus crops.

FEEDING HABITS AND DAMAGE TO HOST PLANTS

Of the cucurbit host plants in Ceylon *L. membranaceus* preferentially feeds upon bitter-gourd (*Momordica charantia*) and if this plant is absent in the vicinity, luffa (*Luffa acutangula*) is attacked. Snake-gourd (*Trichosanthes anguina*) is the least attacked by this pest among the cucurbits. In the field where snake-gourd and bitter-gourd plantings were found side by side the *L. membranaceus* was found to concentrate its attack entirely upon the bitter-gourd leaving the snake-gourd entirely untouched. Oranges and tangerines are also heavily attacked by this pest.

Leptoglossus membranaceus feeds upon the leaves, stems and fruits of luffa and bitter-gourd. In plantings where the creepers afford poor shade over the fruits the pest feeds upon the fruits during the mornings and evenings. During the hours of strong sunlight the pest leaves the fruits and continues feeding upon the leaves and stems of the plants sheltered by the leaves from the intense sunlight.

Feeding of the pest upon the leaves and the stems of bitter-gourd and luffa results initially in wilting of the creeper beyond the points fed upon. Within 48 hours the parts of the stem and leaves fed upon

PLATE I - *Leptoglossus membranaceus* adults attacking bittergourd

turn yellowish brown. Attacked leaves turn deeper brown, wither and die. Attacked stems remain yellowish brown and usually do not die out as a consequence of the attack except where the attack is concentrated and prolonged. Under these extreme conditions the stems die due to the attack and this leads to the death of the entire creeper. If the attack by the pest is controlled in its initial stages when bug damage and incipient stem damage is apparent and when the plants show only a wilted appearance, the creepers recover in about 8 days and the new growth shows a normal turgid appearance.

Feeding by the pest upon fruits of luffa results in collapse of the pulp, loss of the contents of the seed, shrivelling up of the fruit accompanied by a general necrotic appearance. These fruits are shed prematurely. Fruits of bitter-gourd, which normally are light to deep green in colour depending upon the variety, turn deep orange-red within 24 hours of feeding by *Leptoglossus* (Plate 1). The extent of

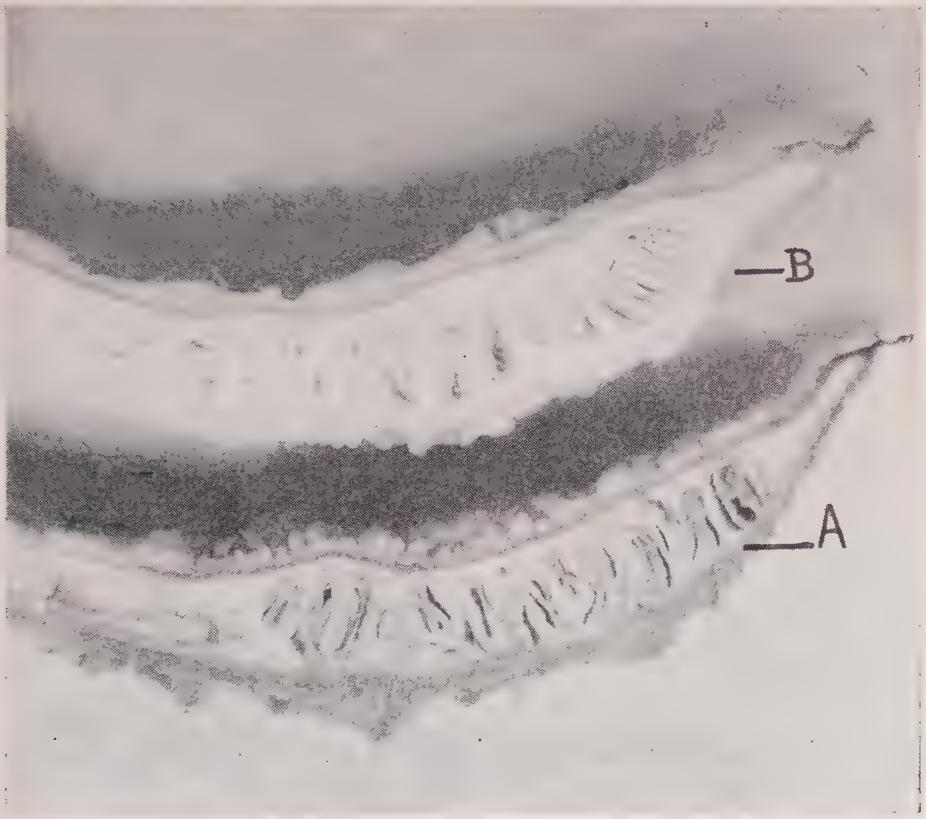

PLATE 2 : Longitudinal sections of bittergourd showing : A—severely attacked fruits with empty seeds and collapsed pulp and B—healthy fruit for comparison

the discolouration depends upon the number of bugs feeding upon the fruits and the duration of the attack. The lightest attack by *Leptoglossus* on the bitter-gourd fruit results in the orange-red discolouration of the surface in small patches. This discolouration reduces the market value of the crop. This response occurs in both mature and immature fruits of bitter-gourd. Internally such attacked fruits show collapsed pulp and empty seed as during feeding the seeds are also reached by the proboscis (Plate 2).

As a consequence of attack on the mature fruits of bitter-gourd by the pest the fruit not only turns deep orange-red in colour rapidly but it also splits open along all the main longitudinal ridges. In this condition the fruits dry on the plant with the longitudinal sections bent backwards towards the stem and bearing hardened seed. Nymphs of *Leptoglossus* are attracted to feed upon such seed. In California the nymphs of *L. zonatus* are recorded to breed upon the seeds of pumpkin in a similar manner (Thompson 1944).

Nymphal feeding is mainly upon the leaves and the stems although when the populations of the bugs on the creepers are extremely high nymphs are also found upon the fruit. They are invariably attracted to dry seed wherever dried fruits are found upon the creepers.

On citrus, feeding is found to be concentrated on the fruits. Attacked fruits show collapsed pulp internally and externally the green rind is discoloured in patches of deep orange-red colour wherever feeding has occurred. Attacked fruits are shed prematurely.

CONTROL OF LEPTOGLOSSUS

Whenever this insect is found damaging crops it usually appears in very large numbers. Consequently loss of crop is very rapid and heavy. Control measures must therefore necessarily not merely be effective but also rapidly applicable.

In the past the only available but relatively ineffective method of control of this pest was by handpicking and destruction of the pest. During the last epidemic of the pest which occurred between March and May 1957 various methods for the quick and effective control of the pest were investigated. The possibility of spraying for the control of the pest was examined first. Using knapsack sprayers it was found that application of the spray was very slow requiring about 5 hours to treat one acre of gourd crop. This was due essentially to the nature of gourd cultivation which rendered walking under the creepers to get proper coverage of the crop with the spray extremely difficult. Coverage of the crop by this method of treatment was incomplete and the spray operator was severely exposed to the spray mist which contaminated the exposed parts of his body and clothes

PLATE 3 : Controlling *Leptoglossus* infestation of bittergourd by powerdusting

within a short time of the commencement of the operations. Furthermore the pest flew away at the disturbance of the crop caused by the approach of the spray operator. The use of power sprayers of the mist blower type had many of the defects encountered during spraying with the knapsack sprayer. Finally a major objection to spraying of the crop against the pest was the weekly harvesting of the various types of gourds for immediate marketing and consumption so that the fruits would carry large chemical residues at harvest and for some days or weeks afterwards depending upon the chemical used.

Dusting of insecticides was next tried out. Rotary hand dusters were satisfactory but the results obtained were poor in comparison with those where power-driven dusters of the type represented by the Birchmeier Mistral 11 duster (Plate 3) were used. Seven dust formulations of the five chlorinated hydrocarbon insecticides DDT, Gamma BHC, Aldrin, Dieldrin and Endrin were tested against the pest using the Mistral 11 duster. Dusting at the rate of 20 lb. of dust per acre on the gourd crops was found to give satisfactory coverage of the crop. One acre was dusted by this method in about 5 minutes. All the dust formulations were therefore applied at this

rate. Each treatment was done on a one acre plot. The pest population both as adults and as nymphs was assessed, immediately before the treatment was carried out, by random counting the population of bugs on the pods. All treatments were completed by 10.30 a.m. Assessment of the mortality of the bugs due to the treatments was made by 10 similar random counts of the bug population in each test plot 24 hours later. Table I gives the results obtained in this dusting trial.

TABLE I—Control of Leptoglossus membranaceus *nymphs and adults when treated with various insecticidal dusts at the rate of 20 lb. of dust per acre*

Insecticidal Dusi and Percent Active Ingredients	*BUG POPULATION BEFORE AND AFTER TEST TREATMENTS*					
	Before Treatment		*24 Hours After Treatment*		*Percent Mortality of Bugs 24 Hours After Treatment*	
	Adults	*Nymphs*	*Adults*	*Nymphs*	*Adults*	*Nymphs*
DDT 10 Per cent. ..	203	109	185	57	8·8	47·7
Dieldrin 1 Per cent. ..	163	126	138	102	15·3	19
Aldrin 2½ Per cent. ..	118	92	73	63	38	31·5
Endrin 1.5 Per cent. ..	167	150	114	0	31	100
Gamma BHC 0.5 Per cent. ..	110	56	105	30	4·5	46·4
Gamma BHC 1.3 Per cent. ..	197	178	8	3	95·4	98·3
Gamma BHC 3 Per cent. ..	242	112	2	0	99	100

In those plots where 1.5% and 3% gamma BHC had been applied, knockdown of bugs commenced about one hour after the dusting and was noted to be continuing even 24 hours later. Twenty-four hours after treatments the surviving bugs were sluggish and incapable of co-ordinated locomotion or flight. In the case of other treatments mortality of bugs was markedly slower and almost imperceptible.

As can be seen from Table I, the order of effectiveness of the insecticidal dusts against the adult bugs is as follows in decreasing order of toxicity:—

gamma BHC 3% ——→ gamma BHC 1.3% ——→ Aldrin 2½% ——→ Endrin 1.5% ——→ Dieldrin 1% ——→ DDT 10% ——→ gamma

BHC .6%. From the point of view of the effective control of the pest in the adult stage only gamma BHC 3% and gamma BHC 1.5% dust can be considered as valuable to the cultivator for field application. The effectiveness of the same dusts to the nymphs of the pest is as follows arranged in decreasing order of toxicity:— gamma BHC 3% = Endrin 1.5% ——→ gamma BHC 1.5% ——→ DDT 10% ——→ gamma BHC .65% ——→ Aldrin 2½% ——→ Dieldrin 1%. This data indicates that the susceptibility of the nymphs of *Leptoglossus membranaceus* to the same series of insecticidal formulations is in some respects widely different from that of the adults. Gamma BHC 1.5% and 3% dusts are consistently highly effective against both the nymphs and the adult bugs. Endrin 1.5% dust on the other hand which is of low effectiveness against the adults is completely effective against the nymphs. DDT 10% dust which is relatively effective against the adults shows considerable action against the nymphs. When control of the pest on a field scale is considered however the chemicals. Endrin and DDT have no place on account of their low toxicity to the adult bugs. For effective field control of the pest the insecticidal formulation should both effectively control the adult and the nymphs and this condition is fulfilled by gamma BHC 1.5% and 3% dusts alone.

Although dusting was highly effective in the immediate control of *Leptoglossus* infestations in the field it was found that the pest re-infested the crop in 8 to 10 days after the last dusting with gamma BHC dusts. This re-infestation occurred from two sources. Eggs laid in the field were not killed by the dustings and hatched out after the dusting to give a very high pest population on the crop. Adult bugs from wild plant hosts in the surrounding forests were able to establish themselves on the crop usually about 8 days after the last dusting. Dusting had therefore to be repeated to obtain continued control of the re-infestation. In some areas where infestations were extremely heavy, re-infestation occurred eight to ten days after each dusting and dusting had to be repeated three times before the crop ceased to be re-infested.

DISCUSSION

Members of the genus *Leptoglossus* which are of economic importance are all predominantly pests of citrus and cucurbits. Other crops such as cotton, beans, tobacco, tomato and peach are also attacked. While the host plant range for feeding by these pests is wide, plants favoured for their breeding are extremely restricted in all cases. In California *L. zonatus* breeds on pomegranate trees but feeds upon a wide range of host plants including citrus (Ebeling 1950).

In Florida *L. gonagra* feeds on citrus and other plants but breeds on cucurbits, especially the citron melon (Thompson 1944). In Ceylon *L. membranaceus* feeds upon a wide variety of host plants especially citrus and cucurbits but breeding is restricted to cucurbits, especially the bitter-gourd. Hutson (1936) records feeding and breeding by this pest upon snake-gourd during the 1936 epidemic of this pest. However during the 1957 epidemic the pest virtually ignored snake-gourd both as a feeding and a breeding host plant. No breeding by the pest was observed on citrus.

The damage done by *L. membranaceus* to the citrus, bitter-gourd and luffa plants and fruits is very extensive. The wilting of gourd creepers and the immediate discolouration with premature falling of the fruits both of gourds and of citrus fed upon by this pest is strongly suggestive of the presence of highly diffusible toxic component in the salivary secretion of this insect. *Leptoglossus membranaceus* shows a strong preference especially in its nymphal stages for feeding upon the dried seeds of bitter-gourd in the field. *Leptoglossus gonagra* shows a similar preference for the dried seeds of the citron melon in Florida.

The factors influencing the sudden development of enormous populations of this insect, which for many years is only casually found on the cucurbit crop in Ceylon, are not clearly understood. Hutson (1936) suggests that the prolonged drought which preceded the 1936 epidemic of *L. membranaceus* may have upset natural controlling factors of this insect as to permit the unchecked build-up of populations of this insect. The 1957 epidemic of this pest was also preceded by unusual drought conditions and it appears very likely that intense drought plays some part in the build-up of epidemic populations of this pest. A feature of study which was initiated rather late almost at the end of the epidemic was the sex ratio of the bugs. It was noted at that stage that the ratio of males to females was as high as 6 to 1. As no records were maintained on this aspect of the pest population from the beginning of the epidemic no definite conclusions could be arrived at on the basis of this finding.

Before the advent of the synthetic organic insecticides, *Leptoglossus* species were controlled chiefly by hand-collection and crushing, jarring of plants early in the mornings and collection of the bugs into cans of oil. In California, at one time, tent fumigation was resorted to for the control of this insect (Ebeling 1950). Pyrethrum and sabadilla dusts (Watson 1940, Friend 1947) were followed by DDT treatments (May 1946) which recorded fair control of pests of this genus. The results of the present trials show that the possibility of sprays to control the pest must be ruled out on account of the obstructions to effective spraying of the gourd crop. Complete control

of *L. membranaceus* as adults and nymphs was possible by dusting with a small power duster and using gamma BHC dusts containing 1.3% and higher amounts of the gamma isomer of BHC at the rate of 20 lb. per acre. Dieldrin, Aldrin, Endrin and DDT dusts were ineffective in the control of the pest but Endrin dust gave good control of only the nymphs of *L. membranaceus*. Mortality of bugs in BHC tested plots commenced within one hour of treatment. The .65% gamma BHC dust usually used in Ceylon for the effective control of the rice bug *Leptocorisa variconis* had no effect against *L. membranaceus*. The 1.3% gamma BHC dust was used on a large scale to combat the epidemic of the pest successfully but re-infestation occurred about 10 days after dusting and a repetition of the dusting was required to control the new infestations.

SUMMARY

(1) *Leptoglossus membranaceus*, like other members of the genus which are of economic importance mainly, damages cucurbit and citrus crops. The pest prefers bitter-gourd to other cultivated cucurbits.

(2) The adult and nymphal stages have been described and details of the life-history presented.

(3) The injury caused by the pest to the host plants is strongly suggestive of the presence of a toxic principle in the salivary secretion of this insect.

(4) Seven dust formulations of five chlorinated hydrocarbon insecticides were tested using a power duster and treating at the rate of 20 lb. of dust per acre. Only the gamma BHC 1.3% and 3% dusts gave good control of both the adult and the nymphs.

(5) Susceptibility of the nymphs to the dust formulations other than those of gamma BHC differed considerably from that of the adult to the same insecticidal dusts.

(6) Re-infestation of dusted plots occurred 8 to 10 days after dusting and necessitated re-dusting to effect full control of the pest.

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THE EFFECTS OF TROPICAL FEEDING STUFFS ON GROWTH AND FIRST YEAR EGG PRODUCTION*

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INTRODUCTION

Feed costs are the greatest single item of expenditure in the production of eggs particularly in tropical countries where labour is cheap and where the climatic conditions demand no more than simple inexpensive housing for the birds. The profitability of a poultry enterprise under these conditions would therefore depend very largely on the extent to which feed costs could be reduced. Most tropical countries are fortunate in that oil cakes or oil meals of one sort or another are generally produced locally and thus provide a cheap source of protein. In consequence, it is generally much easier to compound high protein diets for livestock in the tropics than diets with a wide nutritive ratio. In Ceylon, coconut meal is usually available at low cost and forms the basis of most concentrate mixtures for livestock. On the other hand, cereals are often difficult to come by for animal feeding in most tropical countries, as they form the staple diet of the people in these areas. Moreover, the price of cereals is frequently much higher than that of the richer protein concentrates. In Ceylon, cereals are generally priced about twice as high as coconut meal.

One is therefore confronted with quite a different problem in feeding poultry in most tropical countries as compared with temperate countries. Whereas in Europe and America, the ever increasing

* A more detailed study of this subject is presented in *Poultry Science*, 1957.

4--—J. N. B. 19253 (9/57)

economic pressure on protein supplements is resulting in the use of larger quantities of home-grown cereal protein concentrates, in most tropical countries, on the other hand, the expanding human population is utilizing more and more of the available cereals and thereby causing animal production to be largely dependent on the richer protein concentrates like the oil meals. It was therefore of interest to investigate the effect of home-grown tropical feeding stuffs such as solvent extracted coconut meal on growth and production of poultry.

The experiment reported in this paper commenced on June 15, 1954, and concluded on December 31, 1955. Varying levels of solvent extracted coconut meal containing just under 1 per cent. fat and 22 per cent. protein were fed to birds in the chick, grower and layer phases in an attempt to determine the maximum quantity of this cheap feeding stuff that could be incorporated in poultry rations. At the same time, it was also expected that an estimate could be made of the minimum quantity of cereal and animal protein that would be necessary for optimal growth and production under tropical conditions.

EXPERIMENTAL

One hundred and eighty-one S. C. White Leghorn chicks, hatched from a Government farm flock, were divided at random into four groups of 46, 45, 45 and 45 chicks respectively, and reared to the end of eight weeks on the all-mash rations given in Table 1. These rations, which were fed as dry mash, contained 20 per cent. protein and had a fat content ranging from 4.1 to 4.6 per cent. and a fibre content of 3.1 to 8.1 per cent. The chicks were raised on wire floors and each group was brooded under a darkened 100 watt electric bulb for the first 3 weeks. Vaccination of the birds against fowl pox was carried out when they were 11 days old.

At eight weeks from hatching, the chicks were transferred to the grower rations given in Table 2. Birds on ration 1 shown in Table 1 were transferred for the grower phase to ration 1 shown in Table 2. Similarly, rations 2, 3 and 4 respectively shown in Table 2, were fed to birds that were reared as chicks on rations 2, 3 and 4 presented in Table 1. The grower rations were also fed as dry mash and contained 16 per cent. protein, 6.0 to 7.4 per cent. fat and 3.7 to 7.5 per cent. fibre. Inoculation of the birds against Ranikhet (New Castle) disease was carried out when they were 14 weeks of age.

TABLE 1—Composition of Chick Rations

Ingredient	*Ration 1*	*Ration 2*	*Ration 3*	*Ration 4*
Coconut meal (1 per cent. fat) ..	55 lb.	40 lb.	25 lb.	10 lb.
Gingelly cake ..	3 ,,	9 ,,	12 ,,	14 ,,
Cowpea ..	7 ,,	7 ,,	6 ,,	3 ,,
Sorghum ..	15 ,,	25 ,,	40 ,,	55 ,,
Rice bran ..	15 ,,	12 ,,	7 ,,	3 ,,
Fish meal ..	5 ,,	7 ,,	10 ,,	15 ,,
Calcium carbonate ..	285·8 gm.	—	—	—
Manganese Sulphate ..	1·67 ,,	2·50 gm.	3·96 gm.	5·05 gm.
Salt ..	226·8 ,,	226·8 ,,	226·8 ,,	226·8 ,,
Potassium iodide ..	0·0654 ,,	0·0654 ,,	0·0654 ,,	0·0654 ,,
Choline Chloride (21·7 per cent.) ..	285·7 ,,	271·9 ,,	251·3 ,,	216·8 ,,
Vitamin supplement * ..	11·34 ,,	11·34 ,,	11·34	11·34 ,,
Antibiotic supplement †	50·4 ,,	50·4 ,,	50·4 ,,	50·4 ,,
Fish oil emulsion ‡ ..	40 cc.	40 cc.	40 cc.	40 cc.

* Vitamin supplement : guaranteed potency of 2,000 mg. riboflavin, 4,000 mg. pantothenic acid, 9,000 mg. niacin, 10,000 mg. choline chloride and 60 mg. folic acid per pound.

† Antibiotic supplement : guaranteed to contain not less than 10 gm. aureomycin hydrochloride per pound.

‡ Fish oil emulsion : claimed to contain 5,000 International units of vitamin A and 500 International units of vitamin D3 per gram.

TABLE 2—Composition of Grower Rations

Ingredient	*Ration 1*	*Ration 2*	*Ration 3*	*Ration 4*
Coconut meal (1 per cent. fat) ..	40 lb.	30 lb.	20 lb.	10 lb.
Sorghum ..	25 ,,	35 ,,	45 ,,	55 ,,
Rice bran ..	32 ,,	28 ,,	23 ,,	19 ,,
Fish meal ..	3 ,,	7 ,,	12 ,,	16 ,,
Calcium carbonate ..	623·7 gm.	241·5 gm.	—	—
Manganese Sulphate ..	—	—	—	0·2 gm.
Salt ..	226·8 gm.	226·8 gm.	226·8 gm.	226·8 gm.
Potassium iodide ..	0·0654 ,,	0·0654 ,,	0·0654 ,,	0·0654 ,,
Choline Chloride (21·7 per cent.) ..	301·6 ,,	274·0 ,,	239·4 ,,	211·8 ,,
Fish oil emulsion * ..	100 cc.	100 cc.	100 cc.	100 cc.

* Fish oil emulsion : claimed to contain 5,000 International units of vitamin A and 500 International units of Vitamin D3 per gram. Laboratory estimation of the emulsion fed in the grower and layer stages, however, showed that it contained only 1,085 International units of Vitamin A per gram.

The change from grower to layer rations was made at 18 weeks. The birds were sexed at this time and the pullets transferred to individual battery cages which were housed in a well ventilated building. The layer diets corresponding to the different chick and grower rations are given in Table 3. These diets were also fed in the form of dry mash and had a protein value of 16 per cent. with a fat and fibre content ranging from 5.5 to 7.0 per cent. and 3.6 to 7.5 per cent. respectively.

TABLE 3—Composition of Layer Rations

Ingredient	*Ration 1*	*Ration 2*	*Ration 3*	*Ration 4*
Coconut meal (1 per cent. fat) ..	40 lb.	30 lb.	20 lb.	10 lb.
Gingelly cake ..	2 ,,	2 ,,	2 ,,	2 ,,
Cowpea ..	2 ,,	3 ,,	3 ,,	3 ,,
Sorghum ..	25 ,,	35 ,,	45 ,,	55 ,,
Rice bran ..	29 ,,	25 ,,	21 ,,	16 ,,
Fish meal ..	2 ,,	5 ,,	9 ,,	14 ,,
Calcium carbonate ..	658 gm.	397 gm.	—	—
Shell grit ..	3,200 ,,	3,200 ,,	3,200 gm.	3,200 gm.
Salt ..	226·8 ,,	226·8 ,,	226·8 ,,	226·8 ,,
Potassium iodide ..	0·0654 ,,	0·0654 ,,	0·0654 ,,	0·0654 ,,
Choline Chloride (21·7 per cent.) ..	308·5 ,,	287·7 ,,	260·1 ,,	225·6 ,,
Fish oil emulsion * ..	100 cc.	100 cc.	100 cc.	100 cc.

* Fish oil emulsion: See footnote to Table 2.

The calcium, choline, iodine, manganese, niacin, pantothenic acid, phosphorus, riboflavin, salt, thiamine, vitamin A and vitamin D contents of all the chick, grower and layer rations, used in this experiment were estimated, and wherever deficiencies were suspected, adequate supplements were incorporated in the rations as a precautionary measure. In addition, one ounce of freshly chopped grass was given daily to each bird with the mash in the layer stage.

Water was available at all times to the birds and feeding at every stage was *ad libitum*. The mean monthly maximum temperature under the conditions of experiment varied from 87° F. in March to 81° F. in August, while the mean monthly minimum temperature ranged from 70° F. in June to 66° F. in November.

During the chick and grower stages, the birds were weighed to the nearest gram once a week on Tuesdays in the forenoon. Shank length and comb length measurements to the nearest millimeter were also

taken at the same time. After the birds were eighteen weeks old the measurements were taken every four weeks. Analyses of body weight and shank length measurements are presented in this paper.

Some knowledge of the efficiency of feed utilization was also gained during the course of this study. For this purpose, the feed consumed per week by each group of birds was weighed and recorded. The feed was mixed at intervals of approximately four weeks after the ingredients were passed through a 1 mm. sieve.

The eggs laid by the birds were collected daily, marked with the hen and ration number and then weighed and recorded. Analyses of egg production from date of hatching to 500 days, from date of hatching to date of termination of the experiment (564 days) and for the calendar year January 1 to December 31, 1955, have been made. Egg weight analyses have also been carried out.

Mortality during the course of the experiment resulted in the loss of some 11 per cent. of all birds. The major cause of mortality was paralysis following inoculation with live virus against Ranikhet (New Castle) disease.

RESULTS

Chick Stage. Growth rate may be defined as denoting essentially a relation between change in weight and unit of time. In the current analyses, growth rate was studied in the chick stage by fitting the exponential growth curve $y = ae^{bx}$ for each bird, where x represents the age in weeks, y the logarithm of the weight in grams, a the intercept on the Y axis, b the slope of the line or growth constant and e the base of the natural or Naperian system of logarithms. Analyses of variance of the b values were then conducted separately for males and females to determine the significance of differences in growth rate between rations in each sex.

In the males rations 2 and 3 produced significantly better growth than rations 1 and 4, while in the females, rations 1, 2 and 3 were significantly better than ration 4. It will thus be seen that ration 4 which contained the largest proportions of cereal and fish meal produced a very poor growth rate in both sexes. This diet was by far the richest in its content of the essential amino acids, particularly methionine and cystine, and was also obviously rich in animal protein factors. Moreover, it had a low fibre content of about 3.1 per cent. It could be described as being essentially a high energy diet rich in the essential nutrients required for poultry. It may therefore seem paradoxical that such a diet should produce a relatively poor growth rate. But, examination of the four chick rations used in the present experiment clearly indicates that the energy value of the

diets had increased very considerably from ration 1 to ration 4 when the fish meal and sorghum contents were raised from 5 to 15 per cent. and from 15 to 55 per cent. respectively. In consequence, chicks on ration 4 consumed less food than those on the other rations, being about one quarter less than on ration 1. This lowered feed consumption reduced the intake of essential nutrients and thereby caused a decreased growth rate.

The fact that ration 1 significantly depressed growth in males but not in females may be attributed to differences in the qualitative requirement for protein between the sexes. Ration 1 was relatively poor in essential amino acids and had a high fibre content of 8.1 per cent. due largely to the high proportion of coconut meal in the diet. The feed consumption of chicks on ration 1 was higher than that on any other ration.

Rations 2 and 3 consistently produced the best growth rates, with the balance slightly in favour of ration 3 when the results are viewed irrespective of sex. In the light of the subsequent performance in the grower and layer stages of birds on ration 3, the conclusion seems inescapable that this ration combined the optimal energy and nutrient levels most favourable to the economic growth and production of poultry under the conditions of this experiment. It would be seen from this that about 20 to 25 per cent. coconut meal, 40 to 45 per cent. cereal, and 10 per cent. fish meal in the diet would provide the most desirable balance of nutrients.

Analyses of variance of increases in shank length of chicks from hatching to eight weeks showed that the effect of the composition of the diet on the shank length of chicks is fairly similar to its effect on body weight. Ration 3 produced the highest increases in shank length in both sexes.

Grower Stage. In an attempt to lower costs of production it is common practice in many tropical countries to use the relatively less expensive feed ingredients in compounding rations for growers. It was therefore decided that in the present experiment also, some of the more expensive and dispensable feeding stuffs (i.e., gingelly cake and cowpea) should be excluded from grower rations. In consequence, the rations used at this stage contained only four main ingredients—coconut meal, sorghum, rice bran and fishmeal. However, birds which received large proportions of coconut meal in their chick diets continued to receive similar proportions of coconut meal in the grower phase, and so also birds that were on a high cereal and a high fish meal diet in the chick stage received similar diets in the grower stage. This helped to minimise any unaccountable carry over effects of chick diets into the grower phase.

As in the chick stage, growth rate studies for the period 8 to 18 weeks were made by fitting exponential curves for each bird and the b constants were then subjected to analyses of variance. Analyses of variance of the "raw" increases in weight of the bird in grams from 8 to 18 weeks were also carried out. It was found that the general trend of the results was the same in either case, indicating thereby that the equation $y = ae^{bx}$ gave a good fit to the growth curve at this stage.

The significantly better growth rate exhibited by males on rations 2 and 3 in the chick stage was not maintained in the grower stage. Cockerels on rations 1 and 4 gained as rapidly as those on rations 2 and 3. No significant differences were observed.

In the females however, ration 1 induced the best growth rate, though it was not significantly different in this respect from ration 3. The growth rate on ration 3 was also not significantly different from that on ration 2. But as in the chick stage, ration 4 proved to be the poorest.

The end result at 18 weeks was that, when both sexes were combined, the weight of birds on ration 3 was higher than that on any of the other rations.

Analyses of variance of increases in shank length from 8 to 18 weeks showed that in the males the composition of the grower diets had no significant effect on variations in shank length. This result is similar to that obtained in regard to growth rate. In the females, the shank length of birds on ration 1 increased at a significantly greater rate than that of birds on the other rations. This finding corresponds with their relatively high growth rate.

Layer Stage. The average age at first egg ranged from a mean of 184 days for birds on ration 3 to a mean of 192 days for those on ration 4. Analysis of variance of age at first egg showed that the relative composition of the rations had no significant effect on age at first egg.

Tables 4, 5 and 6 show the results of the analyses of variance of egg production in the four groups, from date of hatching to 500 days, from date of hatching to date of termination of the experiment (564 days), and for the calendar year January 1 to December 31, 1955. All three analyses reveal a common pattern of response of the birds to the different rations fed, with rations 3 and 4 exhibiting a marked superiority over rations 1 and 2 in their effects on egg production. These results agree with those of previous investigators in showing that high efficiency rations are most satisfactory for laying birds. The performance of birds on the high efficiency rations 3 and 4 was significantly superior to that of birds on rations 1 and 2 in production, feed efficiency and gain in weight. The mean production figures were 125,

163, 202 and 205 eggs respectively on rations 1, 2, 3 and 4 during the calendar year January 1 to December 31, 1955, while feed efficiency as measured by the number of eggs produced per pound of food consumed during this period, was found to be as follows :—

Ration Number	*Feed Efficiency*
1	1·26
2	1·79
3	2·65
4	1·97

Evaluating these results in terms of current feed costs, it was found that ration 3 which was associated with an average production of 202 eggs per bird during the calendar year was the most economical layer ration that could be recommended to poultrymen in this country. The superiority of this ration was also revealed by the increased gain in weight in the layer stage of birds under this feed regime.

TABLE 4—Analysis of Variance of Egg Production from Hatching to 500 days

Source of variation	*d. f.*	*Mean square*	*F*
Between rations	3	18,750·3	26·9 **
Within rations	70	696·9	
Total ..	73	1,438·8	

** Significant at 1 per cent. level.

	Ration 1	*Ration 2*	*Ration 3*	*Ration 4*
Mean egg production ..	115	149	182	184

Significant difference between means (5 per cent. level) = 17
Significant difference between means (1 per cent. level) = 23

TABLE 5—Analysis of Variance of Egg Production from Hatching to 564 days

Source of variation	*d. f.*	*Mean square*	*F*
Between rations	3	26,169·9	26·6 **
Within rations	70	984·4	
Total ..	73	2,019·4	

** Significant at 1 per cent. level.

	Ration 1	*Ration 2*	*Ration 3*	*Ration 4*
Mean egg production ..	131	169	210	213

Significant difference between means (5 per cent. level) = 21
Significant difference between means (1 per cent. level) = 27

TABLE 6—Analysis of Variance of Egg Production for Calendar Year

Source of variation	*d. f.*	*Mean square*	*F*
Between rations	3	24,886·3	28·5 **
Within rations	70	873·6	
Total ..	73	1,860·5	

** Significant at 1 per cent. level.

	Ration 1	*Ration 2*	*Ration 3*	*Ration 4*
Mean egg production ..	125	163	202	205

Significant difference between means (5 per cent. level) = 19

Significant difference between means (1 per cent. level) = 26

Statistical analyses of egg weight further confirmed the unsuitability of a high coconut meal ration for layers. Egg weights of birds on ration 1 were significantly lower than those of birds on rations 2, 3 and 4, with ration 4 producing the best results. It is interesting to note that whereas only 27 per cent. of the eggs laid by birds on ration 1 reached the weight of 2 oz., as many as 61 per cent. of all eggs laid by birds on ration 4 were over this weight. The decreased egg size of birds receiving the high coconut meal ration may be attributed to amino acid deficiencies.

DISCUSSION

Lack of appreciation of the importance of expressing the nutritive requirements of birds as a function of the productive energy contents of the diet has vitiated much of the earlier work in poultry nutrition. It does not appear to have been generally realised by the earlier investigators that the productive energy content of a diet may be increased to a point where, even the increased nutritive content would not be enough to meet the bird's requirements. Not until Baldini and Rosenberg (1955)* introduced a new rationale for the utilization of DL-methionine in broiler diets was it apparent that the nutritive requirements of poultry when expressed as per cent. of diet must be related to the productive energy content of the diet.

* Baldini, J. T. and H. R. Rosenberg (1955). *Poultry Sci. 34 :* 1301.

Striking confirmation of this view is furnished by the results of the experiment reported in this paper. Chicks reared on a diet containing 55 per cent. cereal and 15 per cent. fish meal failed to show as good growth as those reared on a 40 per cent. cereal and 10 per cent. fish meal diet despite the lower fibre, higher energy and higher essential amino acid content of the former. The simple explanation for this lay in the fact that, on the higher energy diet, the energy requirements of the birds were satisfied before they had consumed enough feed to provide the required amounts of essential nutrients.

On the other hand, when birds are subjected to a low energy nutritional regime, they tend to eat more feed in relation to gain in weight. In the present experiment, it was found that when chicks were fed a diet that was high in its content of coconut meal (55 per cent.) and low in cereal (15 per cent.) and fish meal (5 per cent.), the relative efficiency of feed utilization was poor and feed consumption itself was high. The evidence presented in this paper leaves little doubt that provided the productive energy contents of the diets do not limit the consumption of feed, high energy diets which contained a low percentage of fibre produced a greater growth rate with greater feed efficiency than low energy diets that were high in fibre.

The layer rations experimented with in the current investigation furnish the most critical evidence of the effects of varying proportions of coconut meal in poultry rations. The incorporation of large quantities of coconut meal, up to 30 and 40 per cent. of the layer ration, with a corresponding reduction in the proportions of animal protein and cereal, does not appear to be conducive to either high egg production or large egg size. The most economic level of feeding coconut meal to laying birds would seem to be about 20 per cent., with fish meal and cereal making up approximately 10 per cent. and 45 per cent. of the ration respectively. Rice bran which is the other main ingredient of this ration may form about 20 per cent., depending however on its quality. In the chick and grower stages, there is evidence that the birds could tolerate somewhat larger quantities of coconut meal in their diets without any appreciable detrimental effects on growth, so that the proportions of animal protein and cereal may be correspondingly reduced at such stages.

It would seem then, that although a very high concentration of coconut meal in poultry rations is not to be recommended, it could nevertheless be utilized to a fair extent to lower costs of production in poultry enterprises in many tropical countries. Even at the level of 20 per cent. recommended for layers on the results of this experiment, it would make an appreciable difference in production costs as it is one of the cheapest protein concentrates in the tropics.

SUMMARY

Since cereals form the staple diet of the people in most tropical countries, the utilization of grain for egg production is generally at the expense of human nutritional needs. In consequence, animal production in these areas has tended to become more dependent on the richer protein concentrates like the oil meals which are processed locally.

In an experiment that was designed primarily to determine the maximum quantity of coconut meal that could be incorporated in poultry rations and also the minimum quantities of cereal and fish-meal required to balance such rations, it was found that the high coconut meal diets were not satisfactory for egg production. High energy rations containing not more than 20 per cent. coconut meal proved most satisfactory from the point of view of growth, production, and efficiency of feed utilization. But, where the productive energy contents of the diets were so high as to limit the consumption of feed below the level necessary to provide the nutritive essentials of chicks, it was found that growth was retarded.

A ration containing 20 per cent. coconut meal, 45 per cent. cereal, 9 per cent. fish meal, 21 per cent. rice bran, 2 per cent. gingelly cake, and 3 per cent. cowpea, when adequately supplemented with vitamins and minerals, provided the best balance of nutrients for economic egg production. In the chick and grower stages, however, the birds appear to be able to tolerate somewhat larger quantities of coconut meal in their diets without any appreciable detrimental effects on growth.

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WEED CONTROL IN DRY LAND FARMING *

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SUMMARY

THE FUNDAMENTAL need for weed control in the Dry Zone has been stressed on and off for many years. Recent work at the Dry Zone Research Station, Maha Illuppallama, has indicated that owing to the peculiarities of the soil and climate, tillage for weed control and seed bed preparation results in splash erosion in the *maha* and in wind erosion in the *yala*. Cover crops and mulches keep down weeds to an extent while affording protection against erosion, but the actual degree of weed control is not appreciable. Hence for weed control without damageful soil manipulation, herbicidal chemicals are the only alternatives for the Dry Zone.

It has also been found that early weeding, i.e., within ten days of sowing, is the most beneficial to the crop ; but as it is often impossible to weed mechanically during early days of crop growth owing to adverse soil and climatic conditions, a pre-emergence weedkiller sprayed just after sowing would appear to be the most satisfactory method of weed control. However, as a result of the use of a pre-emergence treatment, there is an accumulation of weedy grasses when the effect of the chemical wears off ; hence to get rid of these, at least two mechanical weedings have been found essential ; while this operation is undesirable from the point of view of erosion control, it has to be adopted until such time as a chemical is found that is exclusively toxic to weedy grasses.

Research on the above lines is being carried out at Maha Illuppallama, but a more fundamental approach to weed control is necessary if the problem is to be scientifically tackled.

INTRODUCTION

The background to the subject of weed control in the Dry Zone is closely linked to the agronomic work carried out at Maha Illuppallama in the years after 1950. Prior to that year, hardly any work of a significant nature had been done on weeds and weed control in any

* Contribution No. 2 from the Division of Dry Zone Research, Maha Illuppallama.

part of the island. Within the last twenty years a few papers appeared on the botanical features of some Wet Zone paddy field weeds (1-9), and a few on some viruses found in certain weeds (5-7). There were also Departmental Circulars and Leaflets advocating hand pulling, harrowing the standing crop and the use of a Japanese rotary weeder for weed control in Paddy. But there was no literature at all on weeds and their control in highland crops such as Maize, Highland Paddy, Kurakkan, Cotton, Groundnut, &c., which the Dry Zone farmer is being ever encouraged to grow on a larger scale.

The role of weeds in the Dry Zone had not however been entirely overlooked ; reports had from time to time stressed their importance in the scheme of Dry Land Farming. An early report (10) stating that " The two big problems we are up against in mechanized highland rotational agriculture are soil erosion and weed control " and another (11) stating seven years later " It is envisaged that in the unirrigable bottom lands Upland Rice will be the main crop and that weed competition will be the chief factor limiting successful cultivation " emphasizes the perennial nature of the weed problem.

The paucity of information on weeds and weed control in highland crops is not a characteristic of Ceylon ; it was until very recent times a feature common to most tropical countries. In view of the studies carried out on insect pests, diseases and their control in the tropics, the lack of corresponding studies on weed control is difficult to explain. In the western countries on the other hand, the systematic study of weeds goes back to the beginnings of this century and can be traced even into the nineteenth. But it was the discovery of the herbicidal properties of 2-methyl-4-chlorophenoxyacetic acid (MCPA) and 2, 4-dichlorophenoxyacetic acid, (2, 4-D) in the early 'forties which gave a fresh impetus and led to an intensification of the study of weed control ; today, as a result of this work, a fairly definite body of data exists in those countries regarding the practical use of numerous herbicidal chemicals as routine operations in the production of a wide range of crops, both cereal and dicotyledonous.

HISTORICAL

As stated in the introduction, the background to the subject of weed control in the Dry Zone is the agronomic work carried out at Maha Illuppallama from 1950 onwards. This work has been reviewed in detail by Abeyratne (12), but a few salient features need to be briefly stated here.

An early finding was that the Dry Zone soils have a coarse blocky structure where the structural bonds are mainly due to the inorganic

colloids. Due to the irreversible nature of these bonds there is a rapid breakdown of structure under the crushing and pulverising action of tillage implements, especially when they are worked under non-optimal moisture conditions. The optimum soil conditions obtain only during very brief periods which themselves are unreliable owing to the peculiar rainfall pattern. A long dry period from June to September when the soil is subject to severe drying is followed suddenly by very intense convectional showers in September to October. The sowing of crops which has to be completed by October demands hurried seed bed preparation. The succeeding rains in November and December do not for the greater period permit the easy operation of implements. The minor growing season from April to June follows a similar sequence of conditions though with increased hazards of ineffective rainfall for adequate crop growth.

As Ceylon lacked a traditional tillage implement for highland cultivation other than the hoe, large-scale tillage had been carried out for many years using the imported mould board plough and later the disc plough, disc harrow and the intercultivator. While these implements were eminently successful in providing a clean seed bed and in controlling weeds, they had the inherent drawback of destroying soil structure and of exposing the soil surface to erosion. Erosion during the *maha* was mainly by the splash of the raindrops which removes the clay from the surface to lower regions of the profile, and with time results in the development of a poorly aerated denser region underlying a sandy upper horizon ; erosion in the *yala* was mainly due to the heavy winds that scour any exposed surface. Crafts (13) citing similar findings on the harmful nature of tillage in semi-arid regions advances the theory that a part at least of the benefits accruing by the use of perennial covers may be the result of the absence of tillage over relatively long periods of years.

Dry Land Farming was thus faced with a peculiarly complex problem. A certain amount of soil manipulation was inevitable in seed bed preparation and in weed control ; but these operations could lead to soil destruction and erosion ; a compromise had thus to be effected between weed control and the degree of erosion or other alternative methods of checking them had to be adopted. Taking the latter course, there were two lines of approach :—(A) The use of mechanical methods of erosion control like sub-soiling, contour listing, &c., and (B) agronomic methods such as mixed cropping, trash mulching and the use of herbicides held any promise of weed control without seriously of herbicides held any promise of weed control without seriously affecting the soil, and at the same time of procuring a reasonable crop yield. But trash mulching itself materially reduced germination when

crops were seeded directly into the mulch although it afforded satisfactory protection against erosion. Thus the use of herbicides presented the most satisfactory method of weed control in highland crops.

While the above is a brief statement of some conclusions arrived at by experience gained at Maha Illuppallama, an experiment of much significance in weed control in the Dry Zone needs to be stated in greater detail. It was conducted at Maha Illuppallama in the *maha* 1954/55 by Abeyratne to study the effects of different time and frequencies of hand weeding on the yields of Highland Paddy. The yields obtained were as follows :—

TABLE I—Effect of Times and Frequencies of Weeding on Highland Paddy Yields

Cultural Operations	*Yield, Lb./Acre*	*Percentage of Control*
Pre-Sowing Treatments		
No Cultivation at Sowing Time	1,301	100
Cultivated at Sowing Time	2,021	155
Time of First Weeding		
10 days from sowing	1,944	100
15 days from sowing	1,666	84
20 days from sowing	1,325	66
Frequency of Weeding		
3 weedings at 10-day intervals	1,614	100
6 weedings at 10-day intervals	1,708	106
Significant difference ..	320	

From the results in Table I it will be seen that Highland Paddy responds to a cultivation at the time of sowing and to another within ten days of that date. A subsequent increase in the number of weedings does not compensate for the initial setback experienced during the earliest days of crop growth where the first weeding was delayed to fifteen and twenty days from sowing. While weeding in these experimental plots was performed with a hoe, the only implement which gave comparable results on a field scale was a tractor or bullock-drawn rotary weeder, for which the optimum spacing was found to be 12 inches between rows and 4-6 inches within.

The significance of the information obtained above is undeniable, but quite often the soil and climatic conditions of the Dry Zone during the *maha* prevent such a program being put into practice—the main reason being that the soil is too wet and sticky for any type of mechanical treatment. When this and the other factors mentioned so far are taken into account, the use of herbicides stands out as the most suitable means of weed control in Dry Land Farming.

THE HERBICIDES (14)

To many, weed control has come to be synonymous with 2, 4-D and MCPA, but these are only two of a range of chemicals that exhibit growth-regulating properties.

Among the earliest chemicals used for weed control in cereals mainly, were sulphuric acid, cupric salts and sodium arsenite. Owing to their obvious disadvantages these were largely replaced in the 'thirties' by the yellow organic dye-stuffs known as the nitrophenols which were found to be selectively toxic to broad-leaved weeds growing in cereal crops. A serious drawback in the use of these phenols however was that they had pronounced mammalian toxicity. The most popular nitrophenol today is 2, 4-dinitro-6-sec-butylphenol (DNBP), yet even this is not entirely free from the danger of mammalian toxicity, especially at temperatures over 70° F. DNBP is marked as the ammonium or alkanolamine salt and the latter preparation is said to be the less toxic of the two. Among the other substituted phenols, the versatile Pentachlorophenol (PCP), which had been used as a fungicide and wood preservative, was found to be the most phytotoxic ; it resembled DNBP in its action on plants and while its toxic hazards to man are considerably lower than those of DNBP, it is very irritant to the skin and eyes and to the mucous membranes of the nose and throat.

A search for better and safer herbicides resulted in the discovery of MCPA and 2, 4-D in 1941 and '42 respectively ; these ranked among the foremost discoveries of agricultural science in the twentieth century and they were superior in all respects to any herbicidal chemical so far known. Their mode of action approximated that of the natural auxins such as β-indolylacetic acid making them effective at astonishingly low rates of application. Today these so-called hormone weed-killers are being used at over 100 million pounds annually in probably as many acres.

Spurred by the discovery of MCPA and 2, 4-D, an intensive search was made for other chemicals of similar herbicidal properties. Thus the years after 1945 saw the development and production of numerous

herbicides, but none of these rivalled the "hormone" weedkillers in their versatility and effectiveness. Among these newer herbicides were the phenyl carbamates, the chloromethyl ureas, trichloracetic acid, dichloropropionic acid, maleic hydrazide and several more ; they were all excellent in some respects but poor in others—hence their relative unpopularity in comparison with 2, 4-D and MCPA.

The most significant discovery since that of 2, 4-D and MCPA however was made by Wain (15) in 1954. He found that the physiologically inactive, substituted w-aryloxy-alkyl-carboxylic acids underwent a β-oxidation in the presence of certain specific enzymes giving rise to physiologically active forms ; thus, ω-2-methyl-4-chlorophenoxybutyric acid (MCPB) was converted to MCPA. Since the specific enzymes necessary for this conversion are not found in every plant, the range of applicability of MCPA was greatly increased, for it could now be applied to crops in the form of MCPB whereas they would have succumbed to MCPA. The clovers are notable examples of plants tolerant of MCPB, but the tolerance of other crops is not yet established.

WEEDICIDES FOR THE DRY ZONE

The brief digression in the preceding paragraphs shows that the range of herbicides is wide ; one has a choice from among the non-selective killers of all vegetation such as sodium arsenite and the chloromethyl ureas, to those that are selectively toxic to some species while being relatively harmless to others, e.g., 2, 4-D. However, the greater majority of these chemicals, especially the newer herbicides, do not appear to be commercially available in Ceylon at the moment.

Realizing the importance of weed control, and the fact that mechanical methods are unsuitable for the Dry Zone, experiments were conducted in the *maha* 1956/57 to evaluate and study methods of application of some of the easily available herbicides. In all, there were three groups of experiments confined to highland crops ; these were as follows :—

(1) A Dose Response Experiment to study the effect of the chemical on the crop itself.

(2) A trial to test the value of a number of herbicidal preparations as pre-emergence weedkillers.

(3) A trial to study the feasibility of using chemical weedkillers in combination with mechanical weeding.

Dose Response Experiment

This experiment was designed to study the effect of DNBP and MCPB on Annual Dhal (*Cajanus cajan*). These chemicals have been reported effective against weeds in leguminous crops in temperate countries by Roberts and Blackman (18), Carpenter (17) and Wain (16).

According to Woodford (19), the value of a Dose Response Trial lies in the fact that the proper evaluation of a chemical as a herbicide has to follow three logical steps :—

(*a*) the effect of the chemical on the crop grown in pure stand,

(*b*) the effect of the chemical on a pure stand of the weed, and,

(*c*) the effect of the chemical on the crop and weed when in association.

From the data thus obtained, one could arrive at the time and concentration of weedicide application which gives maximum weed control with the minimum injury to the crop ; this concentration is not always that which gives a 100 per cent. weed kill.

In the present experiment, DNBP and MCPB were used at the rates of 0.25, 0.50, 0.75, 1.00 and 1.25 gals. of commercial product in 100 gals. water per acre. While the intention was to spray at weekly intervals during the first five weeks of growth, owing to unavoidable circumstances it was possible to spray only when the crop was 14, 25 and 35 days old. The results of this experiment showed that MCPB was toxic to Annual Dhal at all levels and times of application ; DNBP was most toxic only at the two highest levels.

The injuries caused by the two chemicals were characteristic of their mode of action ; MCPB, being a translocated hormone type of weed-killer, was slow-acting and symptoms of injury were not immediately obvious. With time, however, the contortions which appeared on the stems and branches about twenty-four hours after the spray, were followed by a thickening and cracking of their internodes. These swollen regions assumed a crimson pigmentation, and numerous flattened and matted adventitious rootlets were developed through the cracks on their sides. Recovery from these injuries was slow, if at all, and yields were remarkably low.

DNBP, being a contact herbicide, had no lasting effect on the plant. Typical of its action was the scorching of stems and leaves ; where the extent of such damage was small, there was rapid recovery by the development of numerous lateral branches. But a curious feature

noted with DNBP was that toxicity appeared to be greater at all levels of application to plants which were about twenty-five days old. A possible explanation may be that, the plants being young at the time of the first spray, the actual surface which comes into contact with the chemical is small ; at the third spray, the tissues would be mature enough to resist the chemical although the surface exposed is greater ; this however needs further investigation.

Following up the above experiment, a simple field trial was carried out in the *yala* 1957 to study the effect of MCPB on the other legume crops commonly grown in the Dry Zone, namely, Cowpea, Green Gram and Black Gram. These legumes were also highly susceptible to the chemical and showed the same characteristic symptoms of injury. In their case too, the chemical was sprayed at weekly intervals commencing at one week from germination and up to four weeks of age. The rate of application was 0.5, 1.0, 1.5 and 2.0 lb. acid equivalent in 10 gals. water per acre.

MCPB would thus appear to have no place as a weedkiller for use with the common leguminous crops of the Dry Zone ; the possibility of its use with pasture legumes such as *Stylosanthes gracilis* and *Alyssicarpus vaginalis* has yet to be determined.

Pre-emergence Experiments

Reference was made earlier to the experiment which established the value of eliminating weed competition within ten days of sowing ; it was also pointed out, that owing to the irreversible nature of the structural bonds, mechanical weeding could lead to harmful results ; and also, mechanical weeding would often be impossible at the beginning of the *maha* as the soil was too wet and sticky. Since even six mechanical weedings commenced at fifteen days from sowing do not compensate for the initial setback suffered through weed competition, the use of a chemical to keep the seed bed free of weeds for two weeks or even longer appears to be the ideal substitute under these circumstances. Such chemicals which kill weed seedlings without damaging the germinating crop are described as " pre-emergence " weedkillers and chemicals such as DNBP used in this way are best sprayed on the soil just after the crop has been sown ; there are also other chemicals like Dalapon which, to be used as pre-emergence weedkillers, need to be sprayed two or even three weeks before sowing, as they are temporary soil sterilants which kill all types of seeds found in the soil.

Of a range of chemicals tested for their value as pre-emergence weedkillers for use with Sorghum, Maize, Highland Paddy, Cotton and Groundnuts, the best results were obtained with PCP, using 2-4 gallons of a 14 per cent. commercial formulation and DNBP at 0.25 to 0.50 gallons of a 17 per cent. product in 100 gals. water per acre.

The Use of Weedkillers in Combination with Cultural Practices

This method of weed control may appear at first sight to be in variance with the finding that soil manipulation is harmful under Dry Zone conditions. But recourse to such a method arises out of the use of pre-emergence treatments. It was noticed at Maha Illuppallama that following the use of selective pre-emergence weedkillers there was a tendency for the accumulation of weedy grasses once the effect of the chemical was lost. Prominent among such species were *Digitaria ascendans, Dactyloctenium aegyptiacum, Echinocloa colonna* and *Cynodon dactylon.* As these grasses offer serious competition to cereal crops their removal becomes imperative ; but until such time as a chemical is found that is exclusively toxic to these grasses, the use of a mechanical method seems to be the only alternative for their control in cereal crops.

The combination of chemical and cultural methods of weed control in Cotton and Maize in the Southern United States has been reported by Ennis Jr. (20). There, the chemical is applied as narrow bands along the drill rows and the untreated areas between are mechanically inter-cultivated. This combination has been adopted not for reasons similar to that which necessitates its application in the Dry Zone, but rather as an economic measure to reduce the volume of chemical expended.

Two experiments were carried out at Maha Illuppallama in the *maha* 1956/57 to test the value of combined chemical and cultural methods of weed control in highland crops. In the first experiment, Sorghum was given a pre-emergence treatment of DNBP immediately after sowing ; the chemical was applied at the rate of 1.0 gal. of 17 per cent. commercial formulation in 100 gals. water per acre. The pre-emergence treatment was followed by a number of mechanical weedings ranging from nil to four at ten-day intervals, with the first commencing at ten days from sowing. The results of this experiment are shown in Table II.

Sorghum infested with *Celosia argentea*

Sorghum infested with *Digitaria ascendans*

Sorghum—no pre-emergence, no weeding. Dominant weed *Acanthospermum hispidum*.

Sorghum—with pre-emergence, no weeding. Dominant weed *Dactyloctenium aegyptiacum*. Note vigour of crop due to pre-emergence.

TABLE II—Effect of Combining a Pre-emergence Weedkiller with Mechanical Weeding on Yields of Sorghum

Treatments	*Yield, Lb/Acre*	*Percentage of Control*
Chemical Treatment		
* without pre-emergence	3,015	100 *
with pre-emergence	3,700	123
significant difference	370	
Weeding Treatments		
No weeding	1,606	35
1 weeding	2,687	59
2 weedings at 10-day intervals	3,681	80
* 3 weedings at 10-day intervals	4,575	100 *
4 weedings at 10-day intervals	4,237	93
significant difference	585	
Treatment Combinations		
2 weedings only	3,300	74
* 3 weedings only	4,450	100 *
pre-emergence plus 2 weedings	4,062	91
pre-emergence plus 3 weedings	4,687	105
significant difference	827	

(* Taken as control representing the present standard practice.)

From the results in Table II, it will be seen that Sorghum responds favourably both to pre-emergence and to mechanical weeding. While the interaction between pre-emergence and weeding was not significant, the best results were obtained by using three mechanical weedings in combination with the pre-emergence spray. But it may be possible to use only two mechanical weedings after the pre-emergence treatment as this combination is not significantly inferior either to three mechanical weedings alone or in combination with the chemical.

The second experiment combining chemical and cultural methods of weed control was with Highland Paddy. It was a $2 \times 2 \times 2$ factorial with the following treatments :—

without pre-emergence ; with pre-emergence.
without post-emergence ; with post-emergence.
without weeding ; with three weedings.

The pre-emergence treatment consisted of a spray of DNBP at the rate of 1 gal. 17 per cent. formulation in 100 gals. water per acre given just after sowing ; MCPA at 1/3rd gal. 40 per cent. formulation in 100 gals. water per acre sprayed when the plants were 21 days old formed the post-emergence treatment. The three weedings were at 10-day intervals commencing on the tenth day from sowing. The results obtained are shown in Table III :—

TABLE III—Effect of Combining Pre-and Post-Emergence Weedkillers with Mechanical Weeding on Yields of Highland Paddy

Treatments	Yield, Lb/Acre.	Percentage of Control
Chemical Treatment		
* without pre-emergence (D_0)	338	100 *
with pre-emergence (D_1)	623	184
* without post-emergence (M_{10})	599	100 *
with post-emergence (M_1)	361	60
significant difference	63	
Weeding Treatment		
no weeding (W_0)	84	10
* three weedings (W_1)	874	100 *
significant difference	63	
Interactions		
D_0 W_0	16	2·4
D_1 W_0	158	24
* D_0 W_1	660	100
D_1 W_1	1,090	165
M_0 W_0	109	10
M_1 W_0	64	6
* M_0 W_1	1,090	100 *
M_1 W_1	660	61
* D_0 M_0	404	100 *
D_1 M_0	800	200
D_0 M_1	271	67
D_1 M_1	578	143
significant difference	90	
Treatment Combinations		
* D_0 M_0 W_1	800	100 *
D_1 M_0 W_1	1,388	174
D_1 M_1 W_1	800	100
D_0 M_1 W_1	530	66
significant difference	130	

(* Taken as control representing the present standard practice.)

Examination of Table III reveals three significant features. The first is a consistent depression in yield by using the post-emergence spray of MCPA. In view of this fact, the present practice of treating highland cereals with MCPA on the basis of unconfirmed recommendations needs to be seriously reconsidered ; this further stresses the importance of conducting properly controlled Dose Response Experiments before any recommendations are made. The second important feature is the overall yield increase obtained by using the pre-emergence spray of DNBP.

The third feature revealed in Table III is the response of plots with and without pre-emergence treatment to mechanical weeding. The yield increase obtained by weeding plots given a pre-emergence spray, i.e., the difference $(D_1 W_1 - D_1 W_0)$, is nearly one and a half times as great as that obtained by weeding plots that did not receive it, i.e., the difference $(D_0 W_1 - D_0 W_0)$. In other words, weeding has proved more effective in sprayed plots than in unsprayed plots. Does it mean then that the use of a pre-emergence weedkiller has aggravated weed competition in the second and third weeks of crop growth by stimulating the growth of grasses ? If such is the case, it then confirms the presumption that some method of grass control is a necessary supplement to the use of selective pre-emergence weedkillers in highland crops.

There may be yet another explanation for the phenomenon noted above. In untreated plots, weeds compete with the crop while it is still in the soil and up to the time of the first weeding, which may not always be within ten days of sowing. In the treated plots on the other hand, the chemical eliminates competition during the earliest phases of germination and for at least a week after emergence ; these plants are thus at an advantage and are therefore considerably stronger than those in untreated plots ; this is clearly seen in Sorghum, where the plants in plots given pre-emergence are thicker and stouter than those in untreated plots. Owing to the advantage conferred by the pre-emergence, the maximum possible yields of the plants in treated plots would be greater than those of the plants in untreated ones ; hence weeding after the use of a pre-emergence would evoke greater responses than would be obtained by weeding untreated plots.

CONCLUSION

Since they were carried out only during one season, the results of the experiments outlined above are necessarily inconclusive ; but they are indicative of what might be expected by the systematic control of highland weeds, even without the use of chemical methods.

The yield increases obtained may at first sight appear to be fanciful, but as remarked by Ashby and Pfeiffer (21), they are not to be entirely unexpected under tropical conditions.

While the use of herbicides holds the greatest promise of weed control in the Dry Zone their careless application will result in crop losses rather than gains, as happened in the United States and in Europe in the early days following the discovery of 2, 4-D and MCPA. Hence there is an urgent need for more research on the choice and application of weedkillers for Dry Land Farming.

The results of experiments such as those described above are of immediate practical value, but the subject of weed control requires a more fundamental approach, such as the study of the life history of weed species, their ecology and their physiology. Studies are also necessary on the fate of the chemicals in the soil under local conditions and their residual effect on the crops that follow. Individually such studies may have no practical value, but their cumulative effect has a bearing on the ultimate efficiency of a weedkiller under any particular set of conditions. The present experiments have touched only the fringe of the subject ; a vast field yet remains to be explored.

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SOIL CONDITIONS AND SEEDLING BLIGHT OF RICE

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INTRODUCTION

SEEDLING BLIGHT of rice in Ceylon is caused by several pathogenic fungi. Of these *Fusarium moniliforme* Sheld (*Giberella fujikuroi* (Saw.) Wr.) has assumed economic importance in recent years, especially in the Kegalla, Kadugannawa and Gampola tracts. The symptoms associated with this disease were first noticed in the *yala* of 1950, although like symptoms were also noticed in the previous year (Peiris 1951). The causal organism was determined as *Fusarium moniliforme* (*G. fujikuroi*).

As the fungus is to a great extent both seed and soil-borne, it was decided to ascertain the effect of certain soil conditions on its infectivity on seedlings of rice. Of the several environmental factors governing plant growth, soil moisture is one factor over which some control can be exerted through irrigation practices. Using the facilities available for irrigation and drainage in a normal rice field, it may be possible to regulate soil moisture to the detriment of the fungus. Seto (1933) working in Japan found that rice plants growing under dry conditions showed the symptoms of stunting and foot rot, while plants growing under moist conditions showed only the 'Bakanae' symptom, namely, elongation of the plant.

MATERIALS AND METHODS

An isolate of *F. moniliforme* (*G. fujikuroi*) from infected paddy obtained from Nelundeniya was used as the source of inoculum in all experiments. Seed of the variety *Heenati* 309 was inoculated by the

method described by Abeygunawardena, Suriyadasa and Peiris (1956). The inoculum was prepared by washing out the spores from 15 oat agar slants of the fungus, one week old in culture, in 250 ml. of sterile water. Seed was soaked in this suspension for two hours, then transferred to tap water and allowed to soak overnight before being placed under pressure for six days to germinate. Seed used in the control experiments were surface sterilized by dipping in a 0.1 per cent. aqueous solution of mercuric chloride before germination.

Peradeniya paddy soil was air dried, finely ground in a mortar and sieved through muslin cloth till it was reduced to a fine powder. The maximum water-holding capacity of the soil was determined and this value was taken as 100 per cent. saturation of the soil with water. The amounts of water necessary to give the different moisture contents were determined.

The soil was placed in circular glass dishes with a diameter of 12 cm. and a height of 6.5 cm. 500 gms. of soil were placed in each dish and the required amount of water was added and mixed well. Four replicates of a series of soil containing 100, 90, 80, 70, 60, 55, and 50 per cent. of water together with one having the soil flooded were prepared. The germinating seed was sown 25 to each dish. Three replicates were made of inoculated seed and one replicate of uninoculated seed.

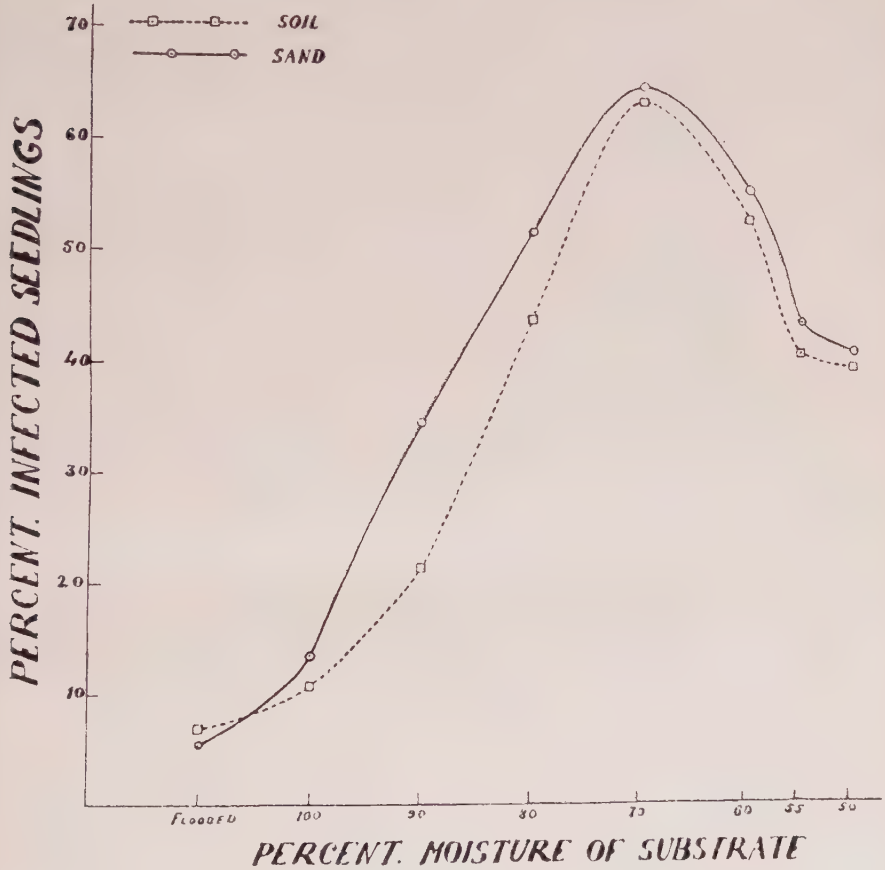
River sand sieved through 2 mm. mesh was used in a parallel experiment. The water-holding capacity of the sand was determined and, as in the soil, four replicates were prepared and sown with inoculated and uninoculated seed.

Four days after the seedlings were sown, those killed by the fungus were removed. This was done to prevent any secondary infection. Removals were thereafter made daily up to 10 days from sowing.

The glass dishes were arranged in a greenhouse bench. During the period of the experiment the water content of each treatment was maintained constant by daily weighing and the addition of water lost by evaporation. Room temperature for this period varied from 77° to 87° F.

EXPERIMENTAL RESULTS AND DISCUSSION

The data obtained in these experiments show that post-emergence seedling blight of rice caused by *Fusarium moniliforme* (*G. fujikuroi*) is closely governed by the moisture content of the substratum. The texture and composition of the soil, however, do not appear to influence the disease. The results for both sand and soil are shown graphically in Fig. 1.



The results were transformed into inverse sine scale and the mean equivalent angles thus obtained were statistically analysed. The results for both soil and sand and their mean equivalent angles are given in Table 1. The analysis of variance is also presented below.

TABLE 1—Effect of Soil Conditions on Seedling Blight

Percentage Moisture content of substratum	*Condition of seed*	*Percentage Seedling Blight*			*Mean equivalent angle*
		Mean of replications		*Mean Soil and Sand*	
		Soil	*Sand*		
Flooded ..	Inoculated ..	6·66	5·33	6·00	12·68
	Uninoculated ..	0	0	0	0
100 ..	Inoculated ..	10·66	13·33	12·00	19·95
	Uninoculated ..	0	0	0	0
90 ..	Inoculated ..	21·33	34·66	28·00	31·32
	Uninoculated ..	0	8·00	4·00	8·20
80 ..	Inoculated ..	44·00	52·00	48·00	43·85
	Uninoculated ..	0	0	0	0
70 ..	Inoculated ..	64·00	65·33	64·67	53·58
	Uninoculated ..	4·00	0	2·00	5·75
60 ..	Inoculated ..	53·33	56·00	54·67	47·68
	Uninoculated ..	0	8·00	4·00	8·20
55 ..	Inoculated ..	41·33	44·00	42·67	40·68
	Uninoculated ..	0	0	0	0
50 ..	Inoculated ..	40·00	41·33	40·67	39·57
	Uninoculated ..	8·00	4·00	6·00	13·95

Significant difference between treatments at P = ·05 = 7·03
Significant difference between uninoculated controls at P = ·05 = 12·17
Significant difference between the uninoculated control and the respective treatment at P = ·05 = 9·94

Analysis of variance of Percentage Seedlings Diseased
Data transformed to inverse sine scale $\theta = \sin. -\sqrt{P}$

	Degrees of Freedom	*Sums of Squares*	*Mean Square*	*F*
Total treatments ..	31	21134·813	681·768	18·949
Soil vs sand	1	62·213	62·213	1·729
Treatments	15	20610·365	1374·024	38·190
Interaction	15	462·235	30·816	0·856
Error	32	1151·327	35·979	—
Total ..	63	22286·140	—	—

Seedling mortality increased progressively with the decrease of the moisture content of the substratum ; under flooded conditions infection was low, with only 6.7 per cent. and 5.3 per cent. of seedlings

diseased, whereas, with a moisture content of 70 per cent., maximum of 64 per cent. and 65.3 per cent. of the seedlings were infected in soil and sand respectively.

The relatively low infectivity of *F. moniliforme* (*G. fujikuroi*) in soil with high moisture content is of practical importance in controlling the disease in the field. The soil moisture content, unlike other soil factors affecting plant growth, can be easily controlled through irrigation. The infectivity of the pathogen can therefore be reduced by saturating the soil.

The present investigation has also shed new light on the behaviour of the pathogen in two extreme types of soil texture and composition, namely, clay and sand. In both clay and sand, infection of rice seedlings followed similar lines as shown in Fig. 1 ; the differences between clay and sand are not statistically significant. Therefore, it may be concluded that the critical factor responsible for seedling mortality is the moisture content of the soil and is not influenced by its texture and composition.

SUMMARY

1. Infectivity of *Fusarium moniliforme* (*Gibberella fujikuroi*) on rice seedlings was investigated in two different soil conditions.

2. Soil moisture appears to be a critical factor governing infection of rice seedlings. A progressive increase in seedling mortality was noted with the decrease in moisture content of the substratum.

3. Infection followed similar lines with both in clay and sand. Soil texture and composition, therefore, do not seem to affect infectivity of the pathogen.

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5—J. N. R 19253 (9/57)

A NOTE ON MAS—AN INDONESIAN VARIETY OF RICE

By J. J. NILES

(Assistant in Economic Botany—Ceylon Department of Agriculture)

YIELDS of the Indonesian variety of rice, *Mas*, have been exceptionally high in Ceylon. Complaints have, however, been received that *Mas* stores badly and flowers irregularly.

STORAGE

The seeds from the *maha* 1955/56 crop of 14 Departmental Stations were tested. Seed samples were stored in (*a*) glass stoppered bottles and (*b*) jute gunny bags, and replicated germination tests were conducted at regular intervals. The mean germination percentages are given in Table 1.

When stored in the bottles the seed from the Stations at Batalagoda, Labuduwa, Anuradhapura, Ambalantota, Murungan, Karadian Aru, Paranthan and Nalanda maintained a germination percentage of over 85 even after one year. On the contrary, the germination of seed from the Stations at Ratalanka, Okkampitiya, Mapalana, Karapincha and Kundasale showed a downward trend in germination of below 85 per cent. from July/September, 1956. A possible explanation of this difference is that the harvested seed had been treated differently at these stations. It is evident that if the seed is well dried and stored in air-tight receptacles the produce of one season can be used for sowing the next corresponding season.

When stored in jute "gunnies", however, germination of seed of all the Stations declined below 85 per cent. by June/November, 1956. The decline was found to set in earlier in the second class of Stations (*vide* Table 1). Seed of *Mas* cannot evidently be stored in gunny bags for even a season and the produce of *maha* should be sown the following *yala*, and *vice versa*. Even heavy seed, separated by immersion in water, declined in germination when stored in gunny bags. The normal practice in Ceylon of storing seed paddy in gunny bags cannot be adopted with *Mas*.

Insect damage does not appear to be a major cause of poor storage ; the last column in Table 1 shows that insect infestation was low. Disease was not a contributing factor. The average bushel-weight of the seed from the 14 Stations was 44 lb., which is one of the lowest recorded. Loose filling of the grain as suggested by the low bushel-weight was possibly the cause of bad storage. There is, however, reason to believe that other factors are also involved.

FLOWERING

Individual panicle emergence dates were recorded in 100 plants of *Mas* and *Murungakayan* 302 grown in parallel rows. The mean number of days between the emergence of the first and the last panicles *within individuals* were 10.2 and 10.5 for *Mas* and *Murungakayan*, respectively. Nevertheless, the range of first-flowering *between plants* was 40 and 23 days for *Mas* and *Murungakayan*, respectively. The appearance of irregular flowering is due to this cause.

SUMMARY

Viability of the rice variety *Mas* can be maintained satisfactorily in air-tight containers, but declines rapidly in jute " gunnies ".

The wide range in flowering dates *between* individual plants is the cause of the appearance of irregular flowering.

(*Received 25 August 1957*)

TABLE I (a)—Mean Germination Percentage of Seed stored in Glass-stoppered Bottles

Station	*Date of Harvest*	*Date of Testing*																		*Damaged by Storage Pests*
		23·4 1956	14·5	4·6	25·6	17·7	9·8	30·8	21·9	12·10	5·11	30·11	20·12	17·1 1957	11·2	8·3	2·4	29·4	28·5	1·7	*Mean Per Cent.*
Batalagoda	17·1·56	96·5	97·0	97·0	96·0	97·0	96·0	98·5	96·0	92·0	93·5	96·5	*67·5*	91·0	97·5	97·5	95·5	77·5	87·5	94·5	0·0
Labuduwa	10·1·56	98·0	99·0	95·5	91·0	93·0	95·0	93·0	92·5	93·5	95·0	91·0	*77·0*	88·0	93·0	93·0	96·0	*71·0*	94·0	92·0	0·0
Anuradhapura	20·2·56	93·0	97·5	95·0	92·0	94·5	97·0	91·0	*82·0*	*68·5*	95·0	90·5	*81·0*	*72·5*	88·0	92·5	95·0	98·0	91·5	89·0	0·5
Ambalantota	—·2·56	100·0	99·0	99·0	96·5	99·0	97·5	98·0	97·0	91·0	96·5	98·5	99·5	89·0	97·0	91·5	97·0	*80·5*	97·5	96·5	0·5
Murungan	22·3·56	98·0	98·5	99·5	97·0	100·0	96·5	99·0	96·5	97·5	98·5	98·0	96·0	98·0	97·5	99·5	98·5	89·0	96·5	97·5	0·0
Karadian Aru. (Research) ..	18·3·56	97·5	98·0	98·0	98·0	100·0	99·0	96·5	97·0	97·5	98·0	98·5	96·5	96·5	99·0	96·5	97·5	94·0	99·0	99·0	0·0
Karadian Aru (Multiplication) ..	2·3·56	*63·5*	85·5	93·5	89·0	93·0	93·5	88·0	89·0	99·0	85·5	91·5	86·0	90·0	90·5	87·5	91·0	86·5	90·5	90·0	0·0
Paranthan	18·2·56	96·0	91·0	94·5	89·0	94·5	93·0	91·0	*81·0*	86·5	92·0	89·0	86·5	88·5	89·5	96·5	87·0	94·5	87·0	*80·5*	0·5
Nalanda	3·4·56	97·0	99·5	99·5	98·0	99·0	97·0	99·0	96·5	86·0	93·5	98·5	93·5	95·5	97·0	97·5	97·5	89·0	95·0	96·0	1·0
Ratalauka	19·1·56	*82·0*	94·0	94·0	87·5	92·5	*78·5*	*80·0*	*65·0*	*63·0*	*78·0*	*81·5*	*83·5*	85·5	*83·0*	98·0	95·0	*78·5*	*84·5*	*71·0*	0·5
Okkampitiya	11·2·56	95·0	98·0	97·0	89·5	91·0	87·0	*81·0*	*77·5*	*59·0*	*84·0*	88·0	*83·5*	*62·0*	90·0	*80·5*	95·0	*80·5*	*80·5*	*79·0*	3·5
Mapalana	27·1·56	92·5	89·0	94·0	88·0	*82·5*	85·0	*82·5*	*76·5*	*65·5*	*84·5*	*66·5*	*59·0*	*81·0*	88·5	86·0	98·5	97·0	*72·5*	*76·0*	0·0
Karapincha	7·3·56	98·0	91·5	95·5	*84·0*	93·5	85·5	85·0	*81·0*	*72·5*	85·0	*79·5*	*73·5*	*79·5*	89·0	87·0	*81·0*	95·5	*77·5*	*74·0*	4·4
Kundasale	25·2·56	98·0	99·5	97·0	96·5	94·5	96·5	98·0	*83·0*	89·0	87·0	89·0	90·5	*79·0*	89·0	*82·0*	*82·0*	95·5	*84·0*	*75·5*	7·5

TABLE I (b)—Mean Germination Percentage of Seed stored in Gunny Bags

Station	*Date of Harvest*	*Date of Testing*																	*Damaged by Storage Pests*
		23·4 1956	14·5	4·6	25·6	17·7	9·8	30·8	21·9	12·10	5·11	30·11	20·12	17·1 1957	11·2	8·3	2·4	29·4	28·5	1·7	*Mean Per Cent.*
Batalagoda	17·1·56	97·5	95·5	95·0	93·0	94·0	90·0	89·5	89·5	*74·0*	*72·0*	*37·0*	*37·5*	*30·5*	*54·5*	*16·5*	*20·5*	*17·5*	*0·0*	*0·0*	5·5
Labuduwa	10·1·56	99·0	98·5	93·0	*83·0*	90·5	*81·0*	*74·5*	*62·0*	88·5	*40·5*	*13·0*	*18·0*	*4·5*	*51·0*	*8·0*	*4·0*	*41·0*	*0·0*	*0·0*	2·5
Anuradhapura	20·2·56	95·0	96·0	88·5	87·5	85·0	88·0	*73·0*	*69·5*	*63·5*	*52·5*	*33·0*	*53·0*	*16·5*	*39·0*	*15·0*	*8·0*	*30·0*	*0·0*	*0·0*	10·0
Ambalantota	– ·2·56	99·5	98·5	98·0	95·0	96·0	96·5	87·5	88·0	89·5	85·5	*45·5*	*45·5*	*50·5*	*73·5*	*33·0*	*26·0*	*17·5*	*3·0*	*0·0*	5·0
Murungan	22·3·56	95·0	99·0	97·0	97·0	97·5	95·0	90·5	94·5	86·0	87·0	*81·5*	*58·5*	*60·5*	*61·0*	*31·5*	*31·0*	*15·5*	*3·0*	*0·0*	*3·0*
Karadian Aru (Research) ..	18·3·56	98·5	99·0	96·5	97·5	95·5	97·0	91·5	88·5	*84·5*	86·0	86·0	*80·0*	*62·5*	*70·5*	*40·0*	*68·5*	*14·5*	*9·5*	*1·0*	3·5
Karadian Aru (Multiplication) ..	2·3·56	*72·5*	85·5	88·5	*82·5*	91·5	88·5	*70·0*	*66·5*	91·0	*73·5*	*65·5*	*65·0*	*60·0*	*58·5*	*39·0*	*35·0*	*20·0*	*28·5*	*12·5*	6·5
Paranthan	18·2·56	96·0	93·5	93·5	90·5	94·5	88·5	*54·5*	*62·0*	*77·5*	*19·0*	*4·5*	*15·5*	*5·0*	*41·5*	*2·0*	*7·0*	*22·0*	*0·0*	*0·0*	5·5
Nalanda	3·4·56	99·0	95·0	94·0	94·0	95·0	92·0	94·0	90·0	85·0	*72·5*	*73·0*	*55·5*	*50·5*	*55·0*	*26·5*	*37·0*	*11·0*	*9·0*	*0·0*	0·5
Ratalanka	19·1·56	91·0	93·0	92·0	*70·5*	*75·0*	*72·5*	*64·0*	*47·0*	*50·5*	*44·0*	*22·5*	*22·0*	*10·0*	*45·5*	*6·0*	*6·0*	*26·5*	*1·0*	*0·0*	3·5
Okkampitiya	11·2·56	94·5	98·0	89·5	*79·5*	*79·5*	*70·5*	*54·5*	*54·0*	*62·5*	*59·0*	*10·0*	*25·5*	*2·5*	*54·5*	*2·5*	*10·0*	*37·0*	*0·0*	*0·0*	9·0
Mapalana	27·1·56	95·5	88·0	*77·5*	*81·5*	*79·5*	*73·5*	*59·0*	*54·0*	*75·0*	*38·5*	*32·5*	*46·0*	*12·5*	*49·5*	*12·5*	*10·0*	*53·0*	*0·5*	*0·0*	8·5
Karapincha	7·3·56	96·5	93·5	91·0	*84·5*	*68·0*	*79·0*	*62·0*	*64·0*	*50·0*	*46·0*	*42·0*	*63·5*	*28·5*	*59·5*	*28·5*	*30·5*	*12·0*	*12·5*	*1·5*	10·0
Kundasale	25·2·56	99·0	97·0	90·0	92·0	*84·5*	*83·0*	*79·0*	*78·5*	*78·5*	*70·5*	*72·0*	*68·5*	*64·0*	*50·0*	*47·0*	*38·0*	*15·0*	*30·0*	*2·5*	*13·0*

SOME ASPECTS IN THE PLANNING AND ASSESSMENT OF SOIL AND WATER CONSERVATION MEASURES*

By V. E. A. WIKRAMANAYAKE

(Faculty of Agriculture—University of Ceylon)

INTRODUCTION

It is probably true to say that what soil and water conservation in Ceylon suffers from most is the lack of planning. Our agriculturists have never been unaware of the gravity of the problem, but it is only in very recent times that the problems have been studied with a view to planning soil and water conservation measures in relation to land use and other factors. Up to recently soil conservation has been the sole concern of the agriculturist and water conservation that of the civil engineer. The result of this divergence of interest in two interdependent problems has been that soil erosion is still unchecked by the agriculturist, while the civil engineer still uses empirical formulae and runoff coefficients for the calculation of runoff. Mathematically speaking, runoff is a difference and not a product—the difference between rainfall and "losses" such as infiltration, interception by vegetation, surface storage, &c. For lack of information on these phenomena the civil engineer still uses formulae of the type

$$Q = 645\ M^{\frac{3}{4}}$$

where Q is the "yield" of a catchment and M the area of the catchment in square miles. Such a relationship is extremely empirical and takes no account of the variations in infiltration, interception and surface storage due to changes in land use. Soil and water conservation is therefore one field of study and has in recent times become an important aspect of Agricultural Engineering.

* Reproduced from a paper read at the annual sessions of the *Ceylon Association for the Advancement of Science* held at Colombo in December 1956.

THE UNIT FOR PLANNING

Rainfall is our only source of water and the aim of conservation is to utilize as much as possible of it without damaging our resources. The main source of damage is to the soil by erosion, and therefore the need is to obtain in our streams and rivers water free from soil as much as possible. Since the streams and rivers are the ultimate channels to which runoff flows, it follows that any plan of soil conservation should cover the whole drainage basin or catchment area of the stream. Hence, the unit on which a plan of conservation is made should be the catchment area. From the agriculturist's point of view the small catchment, i.e., the catchment of small streams and natural draws, rather than the large catchments (the catchment area of a river) is the obvious unit on which conservation planning should be applied.

THE RUNOFF HYDROGRAPH

In the planning of soil conservation measures on a catchment area it is necessary to know the relationship between rainfall and runoff on the catchment area. The runoff picture of any catchment during a rainstorm is expressed in the form of the hydrograph, which shows the rate of runoff from the catchment at every moment of the duration of the storm. The runoff is measured at the point of outlet. A hydrograph is limited as a means of assessing the behaviour of a crop complex and soil conservation measures during a storm, but is useful in the comparison of two or more treatments. Figures I and II show the hydrographs resulting from the same storm on two adjoining catchments (C-1 of 15 acres and C-3 of 21 acres).

C-1 was under a sparse cover of a young pasture mixture and C-3 was contour ploughed. The hydrographs are markedly different and show that a large proportion of the rainfall was held on one catchment, and ran off the other. Hydrographs by themselves are only useful for the comparison of two catchments. Even though the two catchments referred to were adjoining each other the disparity between the storm patterns on them is apparent from the rainfall histograms. When the catchments are farther apart this disparity will be greater, and comparison of two catchments some distance from each other will be impossible. Further analysis of the hydrograph is necessary to increase its usefulness.

THE INFILTRATION APPROACH

An analysis of the hydrograph in relation to the rainfall record during a storm enables one to obtain a knowledge of the rate at which water is taken up by the soil during the storm (infiltration). The

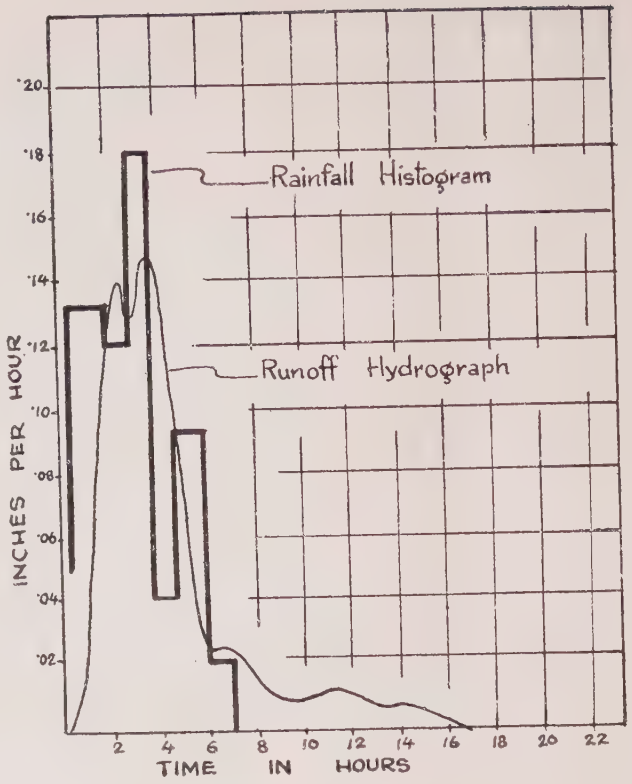

FIG. 1

Rainfall Histogram and Runoff Hydrograph for storm of 1—1—55 on Catchment C—1.

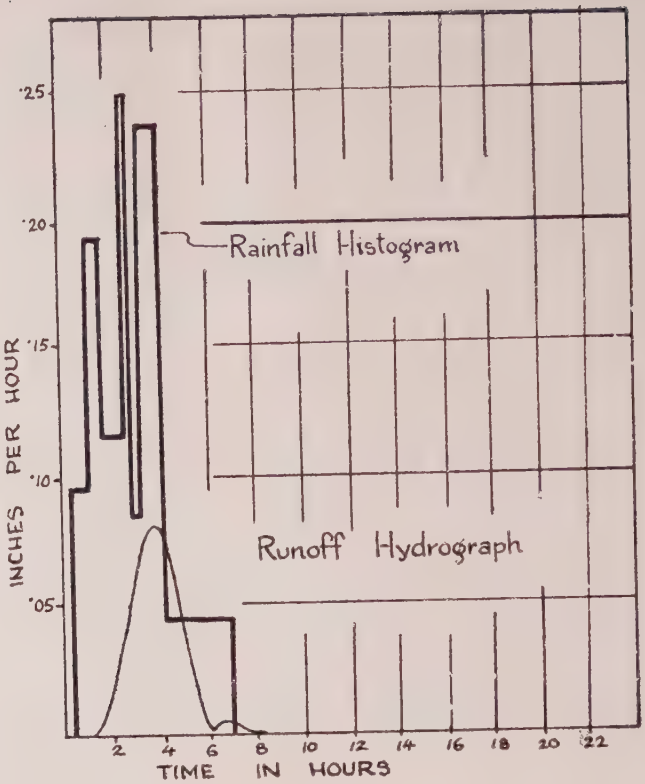

FIG. 2

Rainfall Histogram and Runoff Hydrograph for storm of 1—1—55 on Catchment C—3.

technique is based on the development of the infiltration approach to the calculation of runoff by Horton (1935) and others since, in order to be able to predict runoff from large catchments for any type of storm. The calculation of infiltration has the following advantages :

1. Infiltration is not dependent on slope.
2. On a given soil profile the infiltration picture is unchanging, when the soil is bare, but is very markedly affected by crops grown on the land. Hence, it provides an index of improvement of the land from the point of view of soil and water conservation, and also provides a means of comparison of the effects of different crops and covers.
3. Infiltration data can be compared with each other irrespective of the nature of the storms from which they were computed.

INFILTRATION CURVES

The data on infiltration is obtained in the form of an infiltration curve. An infiltration curve shows the maximum rate of infiltration (the infiltration capacity) throughout the storm period and has a characteristic form. At the beginning of a storm period infiltration capacity is high and gradually decreases until it reaches a minimum value. Fig. 3 shows two infiltration curves for the same plot of land. Curve A was worked out when the plot was under a mixed pasture and curve B when the plot was bare. In both cases soil moisture was at near field capacity. The difference is marked and affords an easy comparison between the two conditions. A high minimum infiltration capacity is desirable since greater infiltration means less surface runoff and possibly more sub-surface runoff. Differences in land use will result in different types of infiltration curves.

REQUIREMENTS FOR THE COMPUTATION OF INFILTRATION CURVES

An infiltration curve can be computed from a continuous record of rainfall and runoff during a storm either from a catchment, a small plot under natural rainfall or a small plot under artificial rainfall (infiltrometer). The infiltration capacity at any moment during a storm is worked out by subtracting the sum of the runoff, interception by cover, depression storage, and surface detention from the rainfall. Hence it follows that infiltration curves can be computed only when the rainfall exceeds infiltration capacity and thereby causes surface runoff.

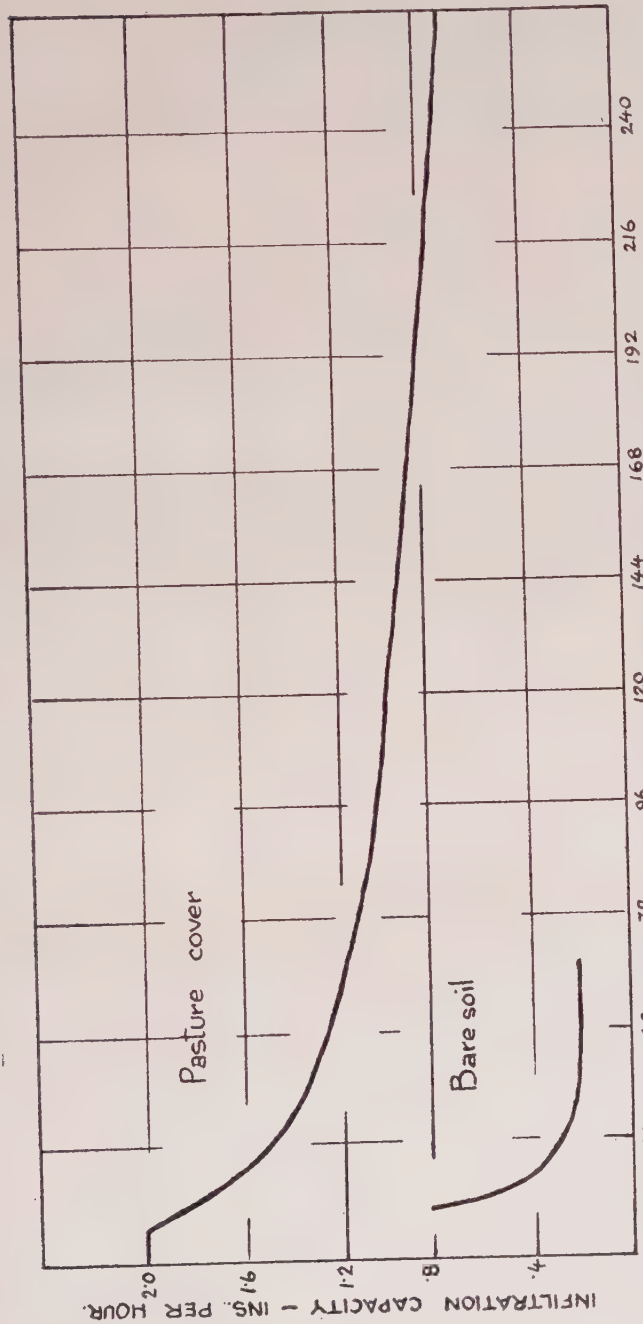

FIG. 3

Infiltration Curves for the same plot under two surface conditions.

The infiltration curve can be a most useful tool in the hands of the soil and water conservation engineer. A continuous record of rainfall and runoff on a catchment will provide information that can show the overall improvement or otherwise that is taking place on the catchment as a result of conservation measures. Infiltration curves can be worked out on small plots to study the effect of various soil-crop complexes on conservation.

CONCLUSION

Both the hydrograph and the infiltration curve derived by its analysis are essential in the planning and assessment of soil conservation measures. Although the hydrograph has limitations it can still be used to advantage in determining the efficacy of measures taken to increase surface storage (or depression storage) such as contour bunds, listing, &c. The infiltration curve however is invaluable in assessing the progress of overall improvement on a catchment, and in determining the runoff capacity required by mechanical measures such as graded terraces and vegetated waterways. The planning and assessment of soil conservation measures cannot be done by rule of thumb and visual observation. The key to planning is the study of the hydrology of each catchment area.

THE INFORMATION SERVICE IN RELATION TO AGRICULTURAL EXTENSION IN CEYLON

By D. E. SCHOKMAN

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AGRICULTURAL PROGRESS depends on people. How far people progress depends to a large extent on the accurate and reliable information they receive. When this information is presented to people in a way designed to increase production and improve their manner of living, it is called *extension information.*

The objectives of extension information are briefly :

1. The improvement of farming methods and a consequent increase in production.
2. The improvement of living conditions.
3. The training of farm youth.
4. The wise use of natural resources—forests, water, soil, &c.

COMMUNICATION

The transmission of this information from the realm of research to its practical application in the field is vital to agricultural development ; it depends greatly on the Information Service which acts as a liaison between the Research Service at one end and the Extension Service serving the farmer at the other.

The Information Service has to collect research findings from its research colleagues and interpret these so that they have a direct bearing on the farmer's problems. The golden rules of communication are that information must :

(1) be simple, understandable and designed to change attitudes ;

(2) be persuasive ;

(3) be accurate ;

(4) be brief and to the point ;

(5) be timely ;

(6) reach the people for whom it is intended.

People learn in different ways—some by hearing, some by seeing and some by doing. Hence the need for a wide variety of communication media such as *advisory bulletins, magazines, press releases, posters, visual aids, radio, exhibitions* and *demonstrations.* These media and their application to local conditions were discussed at length in a previous article published by the writer (*Tropical Agriculturist,* Vol. CXII, 1956). Suffice it to say that every medium has its place in extension campaigns. What needs to be discussed now are the methods by which extension information is made available to the people for whom it is intended.

FIELD EXTENSION METHODS

The active participation of the farming population is a *sine qua non* for the success of extension programmes. In order to achieve this the following methods of approach are suggested:

1. Personal contact—where extension workers visit farmers, study their agricultural systems and suggest ways of improvement.
2. Group contact—where extension workers teach and advise farmers at meetings, demonstrations and tours.
3. Mass contact—where extension makes use of advisory bulletins, visual aids, editorial publicity, radio and exhibitions to put across the agricultural message.

In the first method the extension worker is on his own and success depends on his initiative, personality and understanding of farm people and their problems.

In the other two methods, the co-operation of an efficient Information Service is essential to speed the adoption of improved farming and home practices.

Group Method

The group extension method is undoubtedly the most effective means of " selling " the agricultural message, but unfortunately it is the least exploited in this country.

Above Mr. D. D. Liyanage, Agricultural Instructor, demonstrates the use of the "Ruhuna Paddy Seeder"

Below Livestock shows create interest and apprise people of the latest developments in breeding, feeding and management.

Group extension means the participation of farmers and extension workers in practical seminars. Such seminars bring together people with similar problems to work towards the solution of these problems, and, in the process, to share new experiences and ideas. Seminars serve not only to furnish farmers with the opportunity to discuss their problems with experts in the field, but also help to develop friendships and build up confidence.

The seminar is basically an informal training course or education in a particular agricultural problem. It utilizes a number of teaching techniques, viz., group discussions, illustrated lectures, film strips, tours and demonstrations. Small discussion groups, each led by an extension worker, constitute the heart of such seminars; they encourage members to talk; make them free and comfortable—which is an essential attitude to foster success. Lectures by experts and extension people should make full use of visual aids to engender interest and communicate ideas. Blackboards, illustrated charts, photographs, posters, models and exhibits are all necessary visual aid tools.

The matter for discussion should preferably be a subject that has a majority interest in the particular area. For instance the *Japanese Method of Paddy Cultivation* is a suitable subject for most areas. On the other hand the *Control of the Pentatomid Bug* has to be restricted to those areas where the pest is endemic. The emphasis in group teaching should always be on the practical side. Outdoor demonstrations and arranged tours to visit successful farmers who are adopting the recommendations taught at the seminars are sure-fire propaganda as they operate on the principle of " to see is to believe ".

The duration of the seminar is variable, depending on the number of participants and the subject to be discussed. It should be so organized that about half the time is spent in group discussion. The balance time should be devoted to field trips, studying exhibits and free time. Seminars should be conducted at least twice a year in a particular area. The time in between can be spent in visiting the members, helping them with new techniques, and assessing the effects of the seminar teachings.

Seminars should be sponsored by extension teams, who will rely on the Information Service for the production of visual aids and literature to be used throughout the sessions.

Mass Method

Agricultural advisory services throughout the world make use of campaigns to speed agricultural development, because they realize that the oftener people are exposed to a new idea the more likely they

are to adopt it. *India's successful campaign to spread the Japanese methods of rice culture is an outstanding example.*

In Ceylon we have two annual island-wide campaigns—the Soil Conservation Week which is held in October-November, and the Tree Planting Campaign organized on the lines of the Indian Vana Mahotsava. The effects of these campaigns, however, are ephemeral as they are meant only to remind people of their dependence on natural resources. Proper campaign procedure co-ordinates different methods of communication aimed at focussing attention on a particular problem and its solution over a period of time.

To justify a campaign one must first ascertain (1) whether the problem is sufficiently important to a large number of people, (2) whether the problem can be solved without major or complicated adjustments by the farmer. The Ceylon peasant is poor, and it is useless to ask him to adopt practices that involve a capital outlay which he cannot afford even though he is convinced of their merits.

Secondly, it is necessary to determine how many campaigns can be organized to run concurrently. This will depend largely on a sufficiency of staff and of funds. It is necessary to emphasize that the fewer campaigns undertaken at the same time the more likely they will succeed. Several campaigns aimed at the same people will only tend to confuse both the campaigners and the farmers. Also, mass outlets like the newspapers and radio will be unable to provide space and time for publicity if several campaigns operate simultaneously. To start with, not more than one campaign should be attempted. Those that demand most attention in Ceylon today and which can be developed on an island-wide basis are:—

1. Operation paddy, which should publicise the Japanese methods and local adaptations that may be used to boost production.
2. Operation milk, which should advertise the dietary benefits of wholesome milk and the methods of stepping up production through rearing better breeds, healthy stock, better feeding and adequate housing.

Of course smaller district campaigns may be run to boost local agricultural aspects like *vegetable cultivation in the up-country* or *cigarette tobacco production.*

Whatever the type of campaign, its proper functioning and final evaluation of success will depend on systematic planning and the co-ordination of all communication media.

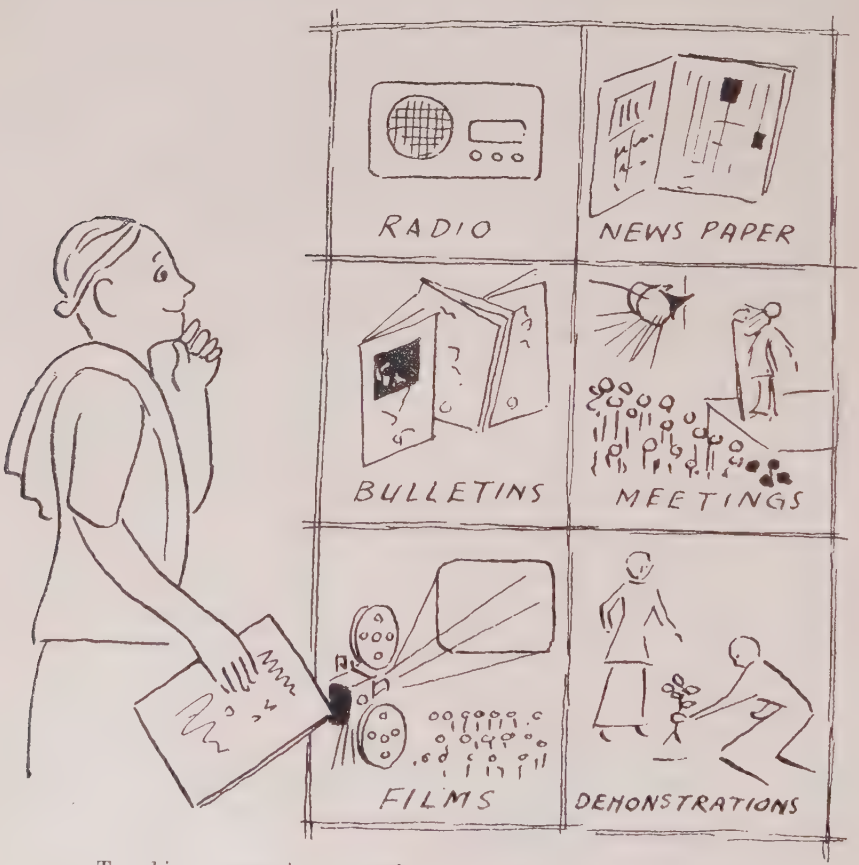
Planning Committee Stage. A team made up of administrators, subject-matter specialists and representatives from the Extension and Information Services should form a steering committee to plan and guide the progress of a campaign.

If this campaign is one that is envisaged to cover several months and is planned on an ambitious scale it will be wise to include on the committee, members of allied departments and commercial concerns that market agricultural commodities.

In enlisting co-operation in all fields of interest you provide for a more useful and fuller campaign.

The steering committee must initially decide on the following points:

1. Objectives of campaign.
2. Duration of campaign.
3. Information to be passed on.
4. Communication media to be employed.
5. Timing of activities.
6. Competitions to be sponsored.
7. List of organizations and potential co-operators to be invited to participate.
8. The budget.



To achieve success in a campaign, use many communication media

Pre-Campaign Preparatory Stage. The next step is to prepare extension workers to operate successfully and the public to benefit from the campaign. To do this most effectively it will be necessary to keep the Extension Service as a whole up to date on the plans of the campaign through a departmental news letter.

In addition, preparatory training classes should be organized to include training on subject-matter and communication skills. Extension workers who benefit from these classes can carry the teaching to Young Farmers' Clubs, village leaders and progressive farmers in advance of, or during the campaign, so that these people will be ready for the impact of the campaign. People who have been apprised in advance of the meaning of the campaign are more receptive and easier to interest or impress by radio, newspapers, leaflets, posters, visual aids, extension meetings and demonstrations.

Launching the Campaign. Once the campaign is ready to start all mass outlets should be advised and brought abreast of developments.

Next, public attention should be focussed on the campaign by arranging for grand "kick-off" meetings all over the Island, in which well known celebrities should be persuaded to take part. Announcement of campaign contests and special parades are other ways of attracting attention. These "interest kindlers" are also first class news value and will find a prominent place in the daily papers.

From now on comes the difficult stage of "operation campaign". The interest of the people should never be allowed to flag. Extension meetings, demonstrations and all other communication media should be brought into operation and continuously flogged till maximum public attention is focussed on the problem. The farmer may first read the information in the newspaper ; he may then hear it on the radio ; sometime later he may attend a meeting where the problem is discussed ; he may also receive a leaflet on the subject from his extension officer. By the time the "Campaign Smash" comes along (in the case of paddy this will be the planting season) the farmer should have all the information he needs to take action successfully.

The campaign now enters its last phase, namely, to help those who have given the idea a try, and report progress and stories of individual farmers who have successfully adopted the recommendations of the campaign. It is here that the personal contact method will pay rich dividends. The Information Service through its press liaison section should make capital of progress reports and success stories. Competition winners should also be given due publicity. Successful men invoke the respect of their less fortunate brethren who would like to emulate their example—they are, therefore, potential grist to the publicist's mill.

Recent posters conceived by the Arts and Graphics Section of the Publicity Division and printed by the Government Press

THE INFORMATION SERVICE

The Information Service has a dual function to perform. It is responsible for obtaining scientific information and interpreting it both to the Extension Service and public, employing as many communication media as possible. It is the job of the Extension Service from there on to spread the message and make the people act on it. The one service purports to inform and interest, the other to inspire and instruct. Another important function of the Information Service is to train others in the use of mass methods. There is need, therefore, for a continuous programme of in-service training for extension workers.

In establishing an Information Service the first step is to—

1. Identify the sources of information.
2. Determine the current problems of farmers.
3. Ascertain the media by which they can be reached.
4. Find out what aids extension personnel require urgently to propagate the message.

The sources of information are all within the Department of Agriculture ; harnessing them for the benefit of the farmer presents

Some magazines and extension bulletins prepared by the Publicity Division and printed at the Government Press

no problem. The other information may be gauged from the replies of extension personnel who are requested to answer a suitable questionnaire.

The next step is to set up the following specialized sections within a unified service to handle all communication media :

1. Editorial Section.
2. Visual Aids and Printing Section.
3. Display and Promotion Section.
4. In-service Training Section.

In addition an adequate *circulation section* or *distributing agency* is very necessary to see that all publicity aids are readily made available to the audiences for whom they are intended and to all those who seek information.

The establishment of a unified service is eminently desirable both from a utility and administration point of view.

Editorial Section. This section will be responsible for producing copy for all extension bulletins and popular magazines, in addition to

editing films and film scripts. It will also maintain liaison with the Press, Radio Ceylon and Government Film Unit, specializing in the preparation of news articles and scripts for broadcasting and filming.

In this connection one must never lose sight of the fact that whatever media are employed—be they poster, picture, advertisement or film—it is by words that the message is brought home.

Visual Aids and Printing Section. Visual Aids include photography, art, exhibits and presentation aids. Black and white photographs are used in publications, feature news stories and as part of exhibits ; they can also be made into feature sets. Film strips and motion pictures are also required for use in extension teaching.

All popular publications require both illustrative art and cover designs. Extension workers need posters and illustrated charts to be used at meetings and demonstrations ; they need exhibits for shows.

Copy, photographs and drawings need to be prepared for the printer and engraver. Attention to typographical detail and a knowledge of printing processes are essential for the production of economic but yet attractive literature designed to interest a majority audience that are not natural readers.

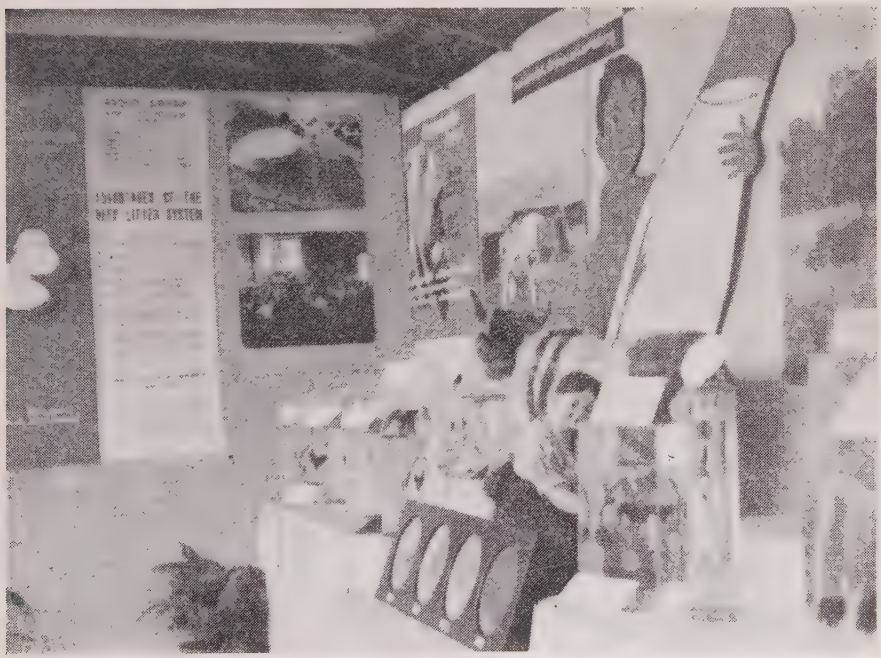
Front view of the Agricultural Pavilion at the Agri-Horticultural Show. Nuwara Eliya, 1957

All this has to be done in the Visual Aids Section, which for convenience and better manipulation should be divided into three sub-sections viz.:

1. Photographic Section.
2. Art Section.
3. Printing Section.

With regard to the printing of agricultural publications, timeliness of issue and a ready availability of material are of primary importance. Furthermore, successful publicity must be unfettered, alive and fascinating.

The acquisition of an easily operated printing machine to produce the general run of reports, handbills, bulletins and small posters will ensure the timely production of a sufficiency of extension literature. The employment of presensitized plates, which are adapted to preparation by normal typewriters, free hand art and photographic processes, together with the use of coloured inks will make possible the quick production of attractive "give away" literature.



A portion of the Animal Husbandry Section at the Agri-Horticultural Show held at Nuwara Eliya, showing the use of posters, photographs, models and other exhibits to propagate the message

The printing of " longer runs " may be continued at the Government Press, which is more qualified by way of staff and equipment to produce these economically.

Silk screen equipment is easy to handle ; it is useful for producing a limited number of large posters for localized campaigns and for printing in at least four colours.

Display and Promotion Section. This section will be chiefly concerned with the erection of pavilions or stands at exhibitions and other shows. The manufacture of counters, self-supporting display units, models and exhibits will also fall within the function of this section. Exhibitions in this country are yet in their infancy, so for the moment their organization may be handled by the Visual Aids Section. But as the popularity of shows increases and the responsibilities of display and promotion become heavier, the Display and Promotion Section will have to function separately as a specialized unit trained in the principles of exhibition technique.

Ceylon, an essentially agricultural country, is woefully lacking in *agricultural shows* aimed at an *agricultural people.* The policy so far has been to bring agriculture in a limited way to general audiences. The policy in future should visualize the presentation of agriculture in a large way to farmers themselves. Whether the emphasis should be on an ambitious provincial exhibition that tours the provinces annually or on lesser local shows that cater to the needs of particular districts is a matter that demands the immediate consideration of the Extension Service. The agricultural display at general exhibitions, however, should always be restricted to a small stand keyed to the particular theme of the host exhibition.

In-service Training Section. In-service training is necessary to prepare extension personnel for dispensing the agricultural message efficiently. The Extension Service has its fingers on the pulse of the farming community. It is the agricultural counterpart of the canvassers and salesmen of the commercial world. Unless extension workers are constantly briefed in the latest information and communication methods, agricultural extension will never succeed. The Extension Service in addition to attempting to sell the message to individuals has the responsibility of educating rural youth and training village leaders. In-service training classes may be conducted throughout the year, catering to groups of extension workers, who will thus be helped to communicate the message in the most desirable and effective way.

In the case of campaign training the first step is to bring together in a handbook all the available pertinent knowledge about the subject. This is a task for subject-matter and communication

specialists. This booklet will provide the raw material for co-ordinating all campaign activities and will form the basis of in-service campaign training. The "guide book" should be made available to all extension personnel. It should contain the following facts:—

1. All information needed for the campaign relating to the problem and its solution.
2. The methods of reaching desired audiences and the communication media to be used.
3. The available visual aids.
4. Details relating to the aims of the campaign and its duration.
5. The scheduled activities of the campaign.
6. Plans to evaluate results.

(Received 15 March 1957)

METEOROLOGICAL REPORT

SUMMARY FOR JANUARY-JUNE, 1957

Dry weather was experienced alternatively with wet weather during January. Dry weather prevailed during the first week of the month and again from 19th to 28th. During the latter period, the nights were very cold and the minimum temperatures several degrees below average. On the 28th the minimum at Nuwara Eliya fell close to freezing point and ground frost was experienced. Wet spells were caused by low pressure waves in Comorin area, but the rainfall received was chiefly moderate. The first wet spell resulted in rain on the east side from 8th to 11th, which was widespread on the 10th. The second spell lasted from 14th to 18th, with widespread rain on the 16th and 17th. The third caused fairly widespread rain on the 29th and 30th. The rainfall was heaviest in the north-eastern hill-country and in the southern parts of Batticaloa District, where the monthly totals generally exceeded 10 inches. Elsewhere over the Island the rainfall was mainly below 5 inches. Least rain (with totals below 2 inches) occurred in the northern and north-western parts, and scattered along the west coast. Rainfall was below normal almost throughout the Island. Greater deficits which occurred in the north-eastern hill-country were of the order of 10 to 15 inches. There were a few scattered excesses.

Active north-east monsoon weather prevailed in the eastern parts of Ceylon during February, while evening thunder activity was fairly frequent in the south-western low and mid-country. The monsoon rain was moderately heavy in the north-eastern hill-country and neighbourhood from 15th to 17th when about 30 daily falls over 5 inches were recorded. These rains resulted in floods in Batticaloa District. Dry weather prevailed over the Island during the periods 5th to 11th, and 21st to 24th. Heavier rain, with monthly totals of the order of 15 inches or more, occurred in the north-eastern parts extending from the north-eastern hill-country up to the coast. Monthly totals of the order of 15 inches occurred in the south-western low and mid-country also. The rainfall was below 5 inches in North-Western Province, in the northern parts of the Island to north of Anuradhapura-Trincomalee and in the southern and south-eastern low country. It was least (totals below 2 inches) in Mannar District and Jaffna Peninsula. The rainfall was above normal over a major part of the Island,

the greater excesses (of the order of 5 to 10 inches) occurring in the north-eastern parts extending from the north-eastern hills up to the coast and scattered in the south-western low and mid-country. Deficits were generally small and occurred scattered, mainly in the northern and north-western parts and in Matara District.

A few afternoon and evening thundery showers were experienced, chiefly inland, during the early part of March. The weather was mainly dry during the rest of the month. Heaviest rainfall occurred in the inland areas in the south, particularly near the hills. Rainfall was below normal except in limited areas in the south.

Afternoon and evening thundershowers continued during April, with short periods of dry weather occasionally. The rainfall was, however, scattered, and mainly confined to the south-western parts. The weather was practically dry in Northern and Eastern Provinces and in the neighbourhood of Hambantota. Heaviest rainfall occurred in Sabaragamuwa Province, where several stations recorded monthly totals exceeding 15 inches. Elsewhere in the western and south-western parts and in the central parts of North-Central Province the monthly totals ranged from 5 to 10 inches. Many stations in Trincomalee District received no rain at all. The rainfall was below normal over a major part of the Island, the bigger deficits being of the order of 2 to 5 inches. Appreciable excesses occurred, in places, in the south-western mid-country, those at some stations ranging from 5 to 10 inches.

The weather was mainly warm and dry during the first half of May, with scattered thundershowers which were fairly widespread occasionally. South-west monsoon conditions became evident from about the 18th, when heavy rain was experienced along the south-west coast, with thundershowers inland and in North-Central Province. These conditions continued generally till about the end of the month, thundershowers extending occasionally to the eastern parts. The monsoon was active during the last 3 days of the month and heavy rain was experienced in the south-western parts, with strong winds over the Island. On the 30th and 31st more than 50 daily falls over 5 inches were recorded. Heaviest rain occurred in the south-western mid-country, where several stations aggregated totals over 20 inches. Rainfall decreased gradually towards the north and the east, monthly totals in the eastern parts being generally below 5 inches. Least rain was experienced in Jaffna Peninsula, where the totals were mainly below 2 inches. Rainfall was irregularly distributed on both sides of average. Bigger deficits (of the order of 5 to 10 inches) occurred in the south-western mid-country. The bigger excesses (also of the order of 5 to 10 inches) occurred to east and south of the central hills, in north-western parts and in North-Central Province.

Active monsoon weather prevailed during June. Rainfall was chiefly confined to the south-western parts, while moderate to strong south-westerly winds were fairly general over the Island. The rainfall was fairly heavy on the 1st and 17th. The rainfall on the 1st which followed two days of heavy rain on the last two days of May resulted in floods in several low-lying areas in Colombo District, Kelani Ganga also rising and remaining above minor flood level (5 feet) from 3rd to 5th. Heaviest rain occurred in the south-western hill-country, where several stations recorded monthly totals exceeding 25 inches, the highest being 42.51 inches at Watawala. In the south-western low country the rainfall was of the order of 10 to 15 inches. Outside the south-west quarter the monthly totals were mainly below 2 inches. Over 60 stations chiefly in the Northern and North-Central Provinces and in Trincomalee District received no rain at all. The rainfall was below normal over a major part of the Island, but the deficits were mainly small.

D. T. E. DASSANAYAKE,
Director, Department of Meteorology.

MAY

	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	Offset	Number of Days
Anuradhapura ..	91·3	+0·5	74·3	—2·1	72	95	8·70	+5·16	19
Badulla ..	86·2	+0·7	67·8	+1·4	69	92	6·69	+2·00	15
Batticaloa ..	89·6	—0·7	77·6	—0·2	66	80	2·27	+0·48	8
Colombo ..	87·6	+0·6	75·9	—1·7	79	93	19·99	+4·50	23
Diyatalawa ..	78·1	—0·6	62·6	+0·6	76	92	8·11	+2·05	20
Galle	85·9	+0·9	76·5	—1·6	82	91	14·68	+2·01	21
Hambantota ..	87·2	+0·4	77·7	+0·1	80	89	2·95	—1·32	16
Jaffna	90·1	+2·0	81·7	0	73	83	1·62	—0·38	6
Kandy	86·1	+0·1	70·3	—0·3	69	90	7·01	+0·50	19
Kankesanturai ..	92·9	+1·0	80·0	—1·5	69	87	1·48	—0·10	10
Kurunegala ..	90·1	+0·9	75·2	—0·9	72	93	8·11	+0·56	19
Mannar ..	91·4	+1·9	79·3	—1·5	73	89	4·30	+2·51	12
Nuwara Eliya ..	71·8	+1·4	53·0	—0·3	77	88	9·27	+0·80	18
Puttalam ..	89·8	+1·4	77·1	—1·8	72	89	9·80	+6·03	18
Ratmalana ..	88·3	+1·0	76·5	—1·4	77	93	17·77	+1·36	23
Ratnapura ..	90·4	+1·4	74·1	—0·8	75	90	14·29	—6·62	24
Trincomalee ..	92·1	—0·1	79·0	+0·2	69	84	2·10	—1·13	7

JUNE

	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	Offset	Number of Days
Anuradhapura ..	88·6	—1·4	76·0	—0·4	72	93	0·57	—0·16	9
Badulla ..	86·4	+1·0	65·7	+0·3	67	89	2·20	+0·66	6
Batticaloa ..	92·0	—0·3	77·8	+0·1	58	74	0·39	—0·50	3
Colombo ..	85·3	—0·1	77·3	0	80	86	9·86	+1·20	22
Diyatalawa ..	77·5	—0·1	63	+0·1	65	79	2·02	+0·06	14
Galle	83·7	+0·1	77·2	0	84	89	4·85	—3·59	22
Hambantota ..	86·4	0	77·6	—0·2	80	89	1·44	—0·67	9
Jaffna	87·2	+0·5	81·9	+1·0	80	81	0	—0·39	0
Kandy	81·6	—0·6	71·2	+0·6	71	83	9·22	+1·92	23
Kankesanturai ..	91·6	+0·4	81·7	+0·7	70	83	0·07	—0·50	1
Kurunegala ..	86·1	—0·5	75·7	+0·1	80	91	10·81	+4·02	21
Mannar ..	88·4	+0·2	81·6	+1·0	74	81	0·03	—0·33	1
Nuwara Eliya ..	66·8	+1·2	56·9	+1·2	81	85	9·60	—0·83	23
Puttalam ..	86·7	+0·3	79·8	+0·6	74	80	2·47	+1·07	13
Ratmalana ..	86·4	+0·9	78·9	+1·5	80	84	9·41	+0·43	21
Ratnapura ..	87·6	+0·8	74·8	+0·1	75	90	21·64	+3·09	26
Trincomalee ..	93·9	+1·6	80·1	+1·0	59	78	0·02	—0·91	1